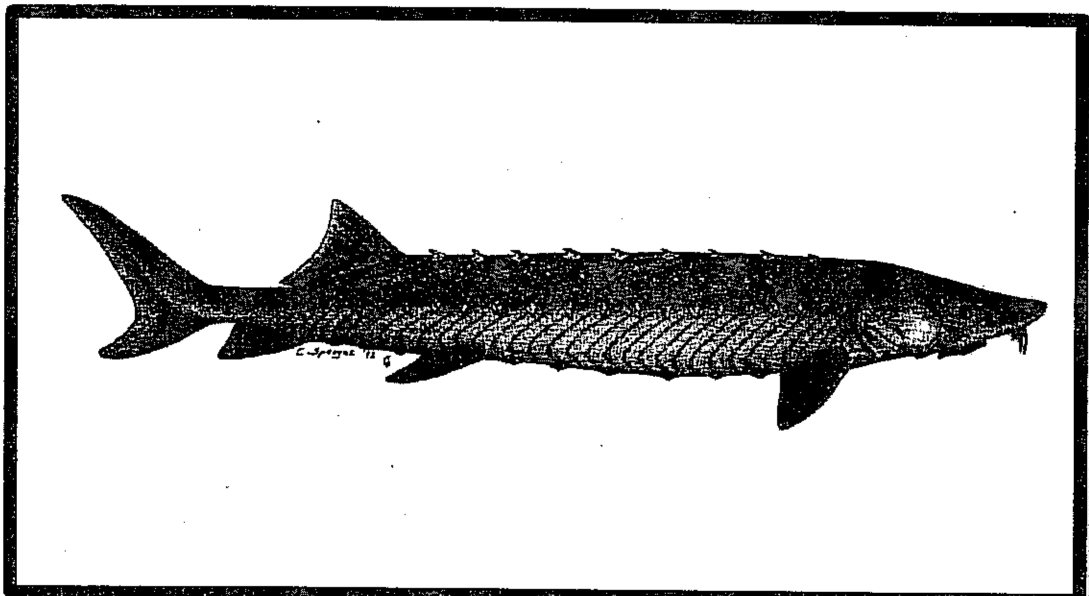
U.S. Fish & Wildlife Service

Recovery Plan for the Kootenai River Population of the White Sturgeon

(Acipenser transmontanus)



Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population

Published by
Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: Anne Badgley
Regional Director, Region 1, U.S. Fish and Wildlife Service

Date: 9/30/99

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Literature Citation: U.S. Fish and Wildlife Service. 1999. Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population. U.S. Fish and Wildlife Service, Portland, Oregon. 96 pp. plus appendices.

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ACKNOWLEDGMENTS

Cover art for this plan was graciously provided by Calvin R. Sprague. The Recovery Plan was prepared by the Kootenai River White Sturgeon Recovery Team comprising the following individuals: [1]

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EXECUTIVE SUMMARY

Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population

Current Species Status: The Kootenai River population of white sturgeon was listed as endangered on September 6, 1994 (59 FR 45989). This white sturgeon population has been in general decline since the mid-1960's. In 1997 the population was estimated to be approximately 1,468 wild fish with few individuals less than 25 years of age. In 1997, the wild population was augmented with the release of 2,283 juvenile white sturgeon reared in the Kootenai Tribal hatchery in Bonners Ferry, Idaho.

Habitat Requirements and Limiting Factors: The Kootenai River population of white sturgeon became isolated from other white sturgeon in the Columbia River basin during the last glacial age (approximately 10,000 years ago). Once isolated, the population adapted to the predevelopment habitat conditions in the Kootenai River drainage. Historically, spring runoff peaked during the first half of June in the Kootenai River upstream of the existing Libby Dam in Montana. Runoff from lower elevations between Libby Dam and Bonners Ferry, Idaho was somewhat earlier, peaking in late May. Combined flows were often in excess of 1,700 cubic meters per second (m^3/s) (60,000 cubic feet per second (cfs)). During the remainder of the year, river flows declined to basal conditions of 113 to 226 cubic meters per second (4,000 to 8,000 cubic feet per second). Annual flushing events re-sorted river sediments providing a clean cobble substrate conducive to insect production and sturgeon egg incubation. Side channels and low-lying deltaic marsh lands were undiked at this time, providing productive, low velocity backwater areas. Nutrient delivery in the system was unimpeded by dams and occurred primarily during spring runoff. Flood plain ecosystems like the predevelopment Kootenai River are characterized by seasonal floods that promote the exchange of nutrients and organisms in a mosaic of habitats and thus enhance biological productivity (Bayley 1995; Junk et al. 1989; Sparks 1995).

Modification of the Kootenai River white sturgeon's habitat by human activities has changed the natural hydrograph of the Kootenai River, altering white sturgeon spawning, egg incubation, and rearing habitats; and reducing overall biological productivity. These factors have contributed to a general lack of recruitment in the white sturgeon population since the mid-1960's.

Recovery Objectives: **Downlisting and Delisting.** The short-term recovery objectives are to re-establish successful natural recruitment and prevent extinction through the use of conservation aquaculture. The long-term objective is to downlist and then delist the fish when the population becomes self-sustaining.

Recovery Criteria: Criteria required for reclassification or downlisting to threatened status include:

1. Natural production of white sturgeon occurs in at least 3 different years of a 10-year period; a naturally produced year class is demonstrated when at least 20 juveniles from a year class are sampled at more than 1 year of age.

2. The estimated white sturgeon population is stable or increasing and juveniles reared through a conservation aquaculture program are available to be added to the wild population each year for a 10-year period. Each of these year classes must be large enough to produce 24 to 120 sturgeon surviving to sexual maturity.

3. A long-term Kootenai River Flow Strategy is developed in coordination with interested State, Federal, and Canadian agencies and the Kootenai Tribe at the end of the 10-year period based on results of ongoing conservation efforts, sturgeon habitat research, and fish productivity studies. An important element of this strategy is demonstration of the repeatability of in-stream environmental conditions necessary to produce recruits (as described above) in future years.

Specific delisting recovery criteria have not been identified at this time, but will be developed as new population status, life history, biological productivity, and flow augmentation monitoring information is collected. However, recovery will not be complete until there is survival to maturity and natural reproduction of juvenile white sturgeon added to the wild population from the conservation aquaculture program. This may take upwards of 25 years since that is the approximate period for juvenile female white sturgeon to reach sexual maturity and reproduce to complete a new generation or spawning cycle.

Actions Needed:

- o Identify and restore white sturgeon habitats necessary to sustain white sturgeon reproduction (spawning and early age recruitment) and rearing while minimizing impacts on other uses of Kootenai River basin waters.

- Develop and implement a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon. The conservation aquaculture program will include protocols on broodstock collection, propagation, juvenile rearing, fish health, genetics, and stocking.

- Work within operational guidelines for Libby Dam based upon Kootenai Integrated Rule Curves (KIRC) developed by Montana Fish, Wildlife, and Parks to balance white sturgeon recovery with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage, and VARQ (an enhanced flood control protocol), to ensure that more water is available for white sturgeon, salmon, and all species in lower water years.

- Continue research and monitoring programs (with achievable and measurable objectives) on life history, habitat requirements for all life stages, population status, and trends of the Kootenai River white sturgeon.

- Protect Kootenai River white sturgeon and their habitats using available regulatory mechanisms.

- Evaluate how changes in biological productivity in the Kootenai River basin affect white sturgeon and their habitats.

- Evaluate the effects of contaminants and possible additional biological threats, e.g. predation and species composition, on Kootenai River white sturgeon and their habitats.

- Increase public awareness of the need to protect and recover Kootenai River white sturgeon.

- Balance white sturgeon recovery measures with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage.

- Secure funding for implementation of recovery tasks.

Estimated Cost of Recovery : Costs for some tasks are estimated to be $7,456,000 for the first 5 fiscal years. Total estimated recovery costs will likely increase as new information is received and as the ongoing biological studies are completed. Estimated costs do not include costs associated with native fish monitoring tasks. Future total costs may also decrease as some research tasks are completed.

Other Physical and Economic Impacts from Recovery: Implementing many of the conservation actions proposed in this recovery plan will create additional economic or environmental impacts, as well as associated benefits, not normally considered in estimating the "costs" of recovery. Economic or environmental impacts may include foregone power generation opportunities, reduced flood control, and possibly negative impacts to other regional resident fish.

Associated benefits include the partial restoration of a more natural Kootenai River hydrograph and flood plain function that benefits resident fish and wildlife. Periodic flushing flows would cleanse Kootenai River gravels and improve aquatic insect production. Improving aquatic ecosystem health leading to improved regional fisheries will provide secondary economic benefits to local communities. Such benefits go beyond the "benefits" typically considered in recovery actions. Conversely, failure to implement proposed recovery actions would have hidden costs that are typically not considered in cost/benefit analysis.

Date of Recovery: At a minimum, at least 25 years following implementation of an approved recovery plan are necessary before delisting of the white sturgeon population can be considered. This 25-year period would allow juveniles added to the population in the first 10 years to reach maturity and begin reproducing a new generation.

What is a recovery plan? A recovery plan is a template for the recovery of threatened or endangered species and their habitats. The recovery plan describes the process by which the decline of a listed species may be reversed and known threats to its long-term survival can be removed. Therefore, recovery is the restoration of a listed species to the point where they become secure, self-sustaining components of their ecosystem.

An approved recovery plan is not a decision document but is intended to provide information and guidance that the U.S. Fish and Wildlife Service believes will lead to recovery of a listed species, including its habitat. The recovery plan provides information necessary to describe the current status of the listed species as well as on-going or proposed actions designed to aid in the species ultimate recovery. Many of the recovery actions (or tasks) in this document will require further environmental analysis and public review, especially those actions taken by Federal agencies.

This final recovery plan serves as a guidance document listing various conservation actions for the recovery of the white sturgeon population within the Kootenai River basin and the ecosystem upon which it depends. It was developed by a recovery team composed of persons from State, Federal, Tribal, and Canadian agencies who have experience with this population of white sturgeon or the threats it faces. Because the white sturgeon population is only one component of its ecosystem, the recovery team took a holistic approach that will address other sensitive aquatic species that are dependent upon the Kootenai River drainage. Efforts proposed for Kootenai River white sturgeon recovery should benefit many other native aquatic species and possibly aid the restoration of declining species in Kootenai River drainage habitats before their status becomes critical. However, actions that will directly benefit the white sturgeon are given highest priority. Other lower priority actions, which could benefit nonlisted aquatic species and further contribute to overall ecosystem recovery, are also included in the recovery plan.

What is the Kootenai River ecosystem? An ecosystem is defined as an ecological community that together with its environment, functions as a unit. For the purposes of this recovery plan, the Kootenai River ecosystem is defined as the habitat and aquatic species complex within the Kootenai drainage basin including Koocanusa Reservoir upstream of Libby Dam, Kootenai River downstream including tributary streams, backwater sloughs, deltaic marshlands, and Kootenay Lake in British Columbia downstream to Corra Linn Dam at the outlet of the West Arm of Kootenay Lake. (Kootenai is spelled Kootenay in Canada.)

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GLOSSARY

Anecdotal Evidence	Information passed along by word of mouth but not documented scientifically.
Bedload	Streambed materials that are washed downstream and redeposited in a new location.
Biological Productivity	A measure of growth in living systems.
Biological Trophic Levels	Steps in the food chain from plants through plant eaters to meat eaters.
Biomass	The total weight of a living organism or a population of organisms.
Chlorinated Biphenyls	A contaminant that accumulates in the fatty tissues of organisms that can cause health problems.
Community Respiration	The amount of energy used by all of the organisms in a specified locality.
Conservation Aquaculture	A hatchery-based, captive culture program designed to 1) preserve the Kootenai River white sturgeon gene pool (genetic variation) and 2) rebuild the natural age class structure of white sturgeon in the wild through the release of hatchery-reared juvenile fish. The program is based on a breeding plan that includes protocols on adult broodstock collection, hatchery spawning and rearing, fish health, and genetics.

Delta (as in tributary)	Streambed materials that accumulate near the mouth of a stream.
Discharge	Water flow volume, usually used to describe a volume released from a dam.
Electrophoretic Analysis	A laboratory technique to examine genetic differences between similar species. Protein samples are placed in an electrical field producing bands on a gel plate. The bands are used like fingerprints to distinguish genetic traits.
Empirical Data	Information derived from measurements made in "real life" situations (e.g. field data).
Flow Ramping	The act of creating a gradual rather than abrupt change in flow. Typically used to define allowable fluctuations below a hydropower dam.
Gas supersaturation	Aquatic conditions that result from turbulence that allows water to absorb nitrogen or oxygen from air bubbles trapped several feet below the surface. As these waters rise back to the surface, they become supersaturated because pressure drops. Some of these gases may become trapped in a fish's blood vessels and cause injury or death.
Habitat Use Curve	A graph describing the distribution/occurrence of fish over a range of a specific environmental variable (e.g. velocity, temperature or depth).

Hydrograph	The recorded variations in stream discharge over time. Useful when comparing effects and changes in stream flow and depth between average natural conditions and altered stream flows (i.e. from dams and diversions).
In-stream Flow Incremental Methodology (IFIM)	A process that uses river channel measurements and hydraulic characteristics to estimate the amount of available fish habitat under various river discharges.
Koocanusa Reservoir	Also known as Libby Reservoir or Lake Koocanusa, located upstream of Libby Dam.
Kootenay Lake	A natural lake in British Columbia, which is regulated by Corra Linn Dam. The Kootenai River, downstream of Libby Dam enters Kootenay Lake from the south.
Limnological (limnology)	The science of the properties of fresh water including water chemistry, density, stratification and physical effects on living organisms.
Load Following	Short-term changes in hydropower operations to respond to subtle shifts in power demand. Flow fluctuations caused by load following are usually less dramatic than power peaking.
Microhabitat	Detailed description of where an animal lives.
Nutrient Dynamics	The way nutrients are used and reused, over time and distance, in a biological system.

Organochlorides	Complex toxic molecule containing carbon and chlorine that is soluble in fatty tissues and can cause health problems.
Photoperiod	A measurement of time exposed to light in a given day or series of days.
Power Peaking	Hydropower operations that occur for short time periods. Typically more power is generated during the day than at night, causing changes in stream flows.
Redox Potential	A measurable electric charge (volts) created when an oxidizing agent pulls electrons away from a reducing agent. This action is an important factor in nutrient cycling in water.
Recruitment	Survival of juveniles until they become a member of the spawning population.
Relative Abundance	A comparison of the number in one category to another (e.g. number of one species to another, male to female, young to old, etc.). Typically expressed as a percentage or proportion.
Reservoir Drawdown	Removing water from a reservoir and lowering the surface elevation.
Scutes	Hard ridges or bony structures along the back of sturgeons.
Tributary	A small stream or river, which enters and increases the volume of the receiving river, lake, or reservoir.
Vermiculite	A mineral mined from the earth having fire retardant and insulating properties.

Year class	All individuals of a fish population spawned and hatched in a given year.

LIST OF SYMBOLS AND ABBREVIATIONS

Act	Endangered Species Act of 1973 (as amended)
B.C.	British Columbia
B.A.	Biological Assessment
B.O.	Biological Opinion
BPA	Bonneville Power Administration
BR	Bureau of Reclamation
cfs	cubic feet per second
C.I.	confidence interval
cm	centimeter
DFO	Canada Department of Fisheries and Oceans
FCRPS	Federal Columbia River Power System
FWS	U.S. Fish and Wildlife Service
IDFG	Idaho Department of Fish and Game
in	inch
IRC	Integrated Rule Curves
kg	kilogram
KIRC	Kootenai Integrated Rule Curves
km	kilometer
KRBSC	Kootenai River Basin Steering Committee
KTOI	Kootenai Tribe of Idaho
lb	pound
MELP	British Columbia Ministry of Environment, Lands and Parks
mi	mile
MFWP	Montana Department of Fish, Wildlife, and Parks
m^3/s	cubic meters per second
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
PCB	polychlorinated biphenyl
ppm	parts per million
Program	Columbia River Basin Fish and Wildlife Program
PSMFC	Pacific States Marine Fisheries Commission
rkm	river-kilometer

rm	river-mile
Service	U.S. Fish and Wildlife Service
U.S.	United States
USACE	U.S. Army Corps of Engineers

PART 1 - INTRODUCTION

A. Overview

On September 6, 1994, the U.S. Fish and Wildlife Service listed the Kootenai River population of white sturgeon as an endangered species (59 FR 45989) under the authority of the Endangered Species Act of 1973, as amended.

The Kootenai River population is one of several land-locked populations of white sturgeon found in the Pacific Northwest. Although officially termed and listed as the "Kootenai River population of white sturgeon", this white sturgeon population inhabits and migrates freely in the Kootenai River from Kootenai Falls in Montana downstream into Kootenay Lake, British Columbia, Canada (Figure 1).

The Endangered Species Act specifies that recovery plans should, to the maximum extent practicable, give priority to those listed species most likely to benefit from recovery actions. The recovery priority for the Kootenai River population of white sturgeon is 3C indicating that: 1) taxonomically, it is a "distinct population segment" of a species; 2) it is subject to a high degree of threat; 3) the recovery potential is high; and 4) the degree of potential for conflict with construction or other development projects is high.

B. General Description

White sturgeon (*Acipenser transmontanus*) occur along the Pacific coast from the Aleutian Islands to central California. In unimpounded river systems, the species migrates between the sea and fresh water, and reproduces in at least three large river systems: the Sacramento-San Joaquin River in California, the Columbia River basin in the Pacific Northwest, and the Fraser River system in British Columbia. The Kootenai River population of white sturgeon is one of 18 land-locked populations of white sturgeon found in the Pacific Northwest. Their distribution extends from Kootenai Falls, Montana, located 50 river-kilometers [rkm] (31 river-miles [rm]) below Libby Dam, downstream through Kootenay Lake to Corra Linn Dam on the lower West Arm of Kootenay Lake, British Columbia.

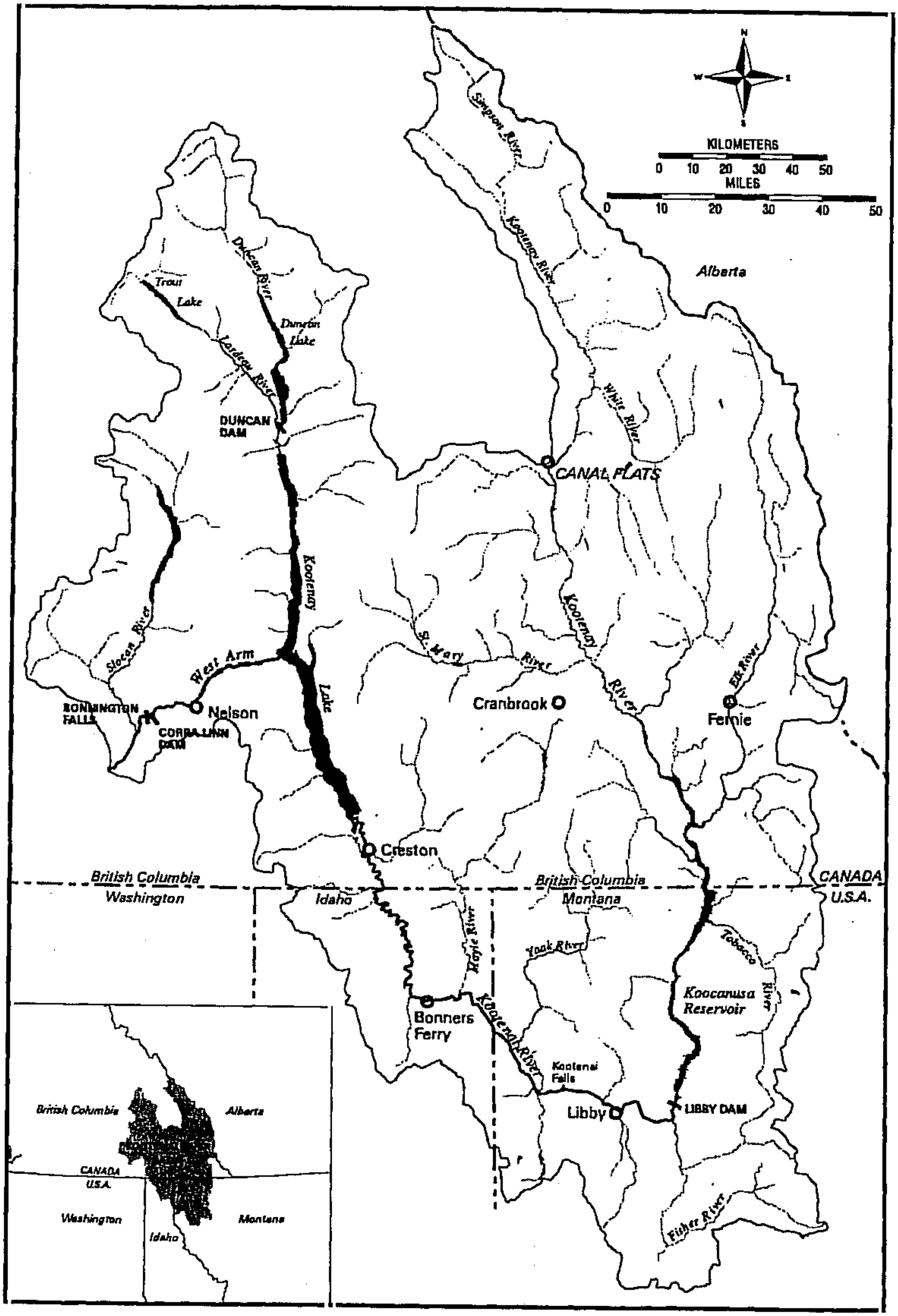

Figure 1. Map of the Kootenai River Basin.

Kootenai Falls may represent an impassible natural barrier to the upstream migration of white sturgeon although anecdotal evidence suggests the historic presence of white sturgeon upstream from Kootenai Falls in Montana and British Columbia. A natural barrier at Bonnington Falls downstream of Kootenay Lake has isolated the Kootenai River white sturgeon from other white sturgeon populations in the Columbia River basin since the last glacial age, approximately 10,000 years ago (Northcote 1973).

White sturgeon are included in the family Acipenseridae, which consists of 4 genera and 24 species of sturgeon. Eight species of sturgeon occur in North America with white sturgeon being one of five species in the genus *Acipenser*. White sturgeon were first described by Richardson in 1863 from a single specimen collected in the Columbia River near Fort Vancouver, Washington (Scott and Crossman 1973). White sturgeon are distinguished from other *Acipenser* by the specific arrangement and number of scutes (bony plates) along the body (Scott and Crossman 1973). The largest white sturgeon on record, weighing approximately 682 kilograms (1,500 pounds), was taken from the Snake River near Weiser, Idaho in 1898 (Simpson and Wallace 1982). Scott and Crossman (1973) describe a white sturgeon reported to weigh over 818 kilograms (1,800 pounds) from the Fraser River near Vancouver, British Columbia, date unknown. Individuals in landlocked populations tend to be smaller. The largest white sturgeon reported from the Kootenai River basin is a 159 kilograms (350 pounds) individual estimated at 85 to 90 years of age captured in Kootenay Lake during September 1995 (Lindsay 1995). White sturgeon are generally long-lived, with females living from 34 to 70 years (PSMFC 1992).

The size or age at first maturity for white sturgeon in the wild is quite variable (PSMFC 1992). In the Kootenai River system, females have been documented to mature as early as age 22 and males at age 16 (Paragamian et al. 1997). Only a portion of adult white sturgeon are reproductive or spawn each year, with the spawning frequency for females estimated at 2 to 11 years (PSMFC 1992). Spawning occurs when the physical environment permits egg development and cues ovulation. White sturgeon are broadcast spawners, releasing their eggs and sperm in fast water. Based upon recent studies, Kootenai River white sturgeon spawn during the period of historical peak flows from May through July

(Apperson and Anders 1991; Marcuson 1994). Spawning at peak flows with high water velocities disperses and prevents clumping of the adhesive eggs. Following fertilization, eggs adhere to the river substrate and hatch after a relatively brief incubation period of 8 to 15 days, depending on water temperature (Brannon et al. 1984). Recently hatched yolk-sac larvae swim or drift in the current for a period of several hours and then settle back into interstitial spaces in the substrate. Larval white sturgeon require an additional 20 to 30 days to metamorphose into juveniles with a full complement of fin rays and scutes.

Historically (pre-Libby Dam construction and operation), spawning areas for white sturgeon were not specifically known. White sturgeon monitoring programs conducted from 1990 through 1995 revealed that white sturgeon spawned within a 19 river-kilometer (12 river-mile) stretch of the Kootenai River, primarily from Bonners Ferry downstream to the lower end of Shorty's Island (Figure 2).

White sturgeon in the Kootenai River system and elsewhere are considered opportunistic feeders. Partridge (1983) found white sturgeon more than 70 centimeters (28 inches) in length feeding on a variety of prey items including clams, snails, aquatic insects, and fish. Andrusak (MELP, pers. comm., 1993) noted that kokanee (*Oncorhynchus nerka*) in Kootenay Lake, prior to a dramatic population crash beginning in the mid-1970's, were once considered an important prey item for adult white sturgeon.

Partridge (1983) noted that white sturgeon recruitment was intermittent and possibly decreasing from the mid-1960's to 1974 when Libby Dam started operations. This is demonstrated by the absence of white sturgeon year classes in samples collected in the early 1980's (i.e. 1965 to 1969, 1971, and 1975). Partridge speculated that the lack of recruitment in certain years was due in part to (1) the elimination of rearing areas for juveniles through diking of slough and marsh side-channel habitats; and (2) the increase in chemical pollutants, e.g. copper and zinc, released in the past from mineral processing facilities, which may have affected spawning or recruitment success.

Previous estimates of population size suggested that the Kootenai River white sturgeon population had declined from an estimated 1,194 fish in 1982 (Partridge

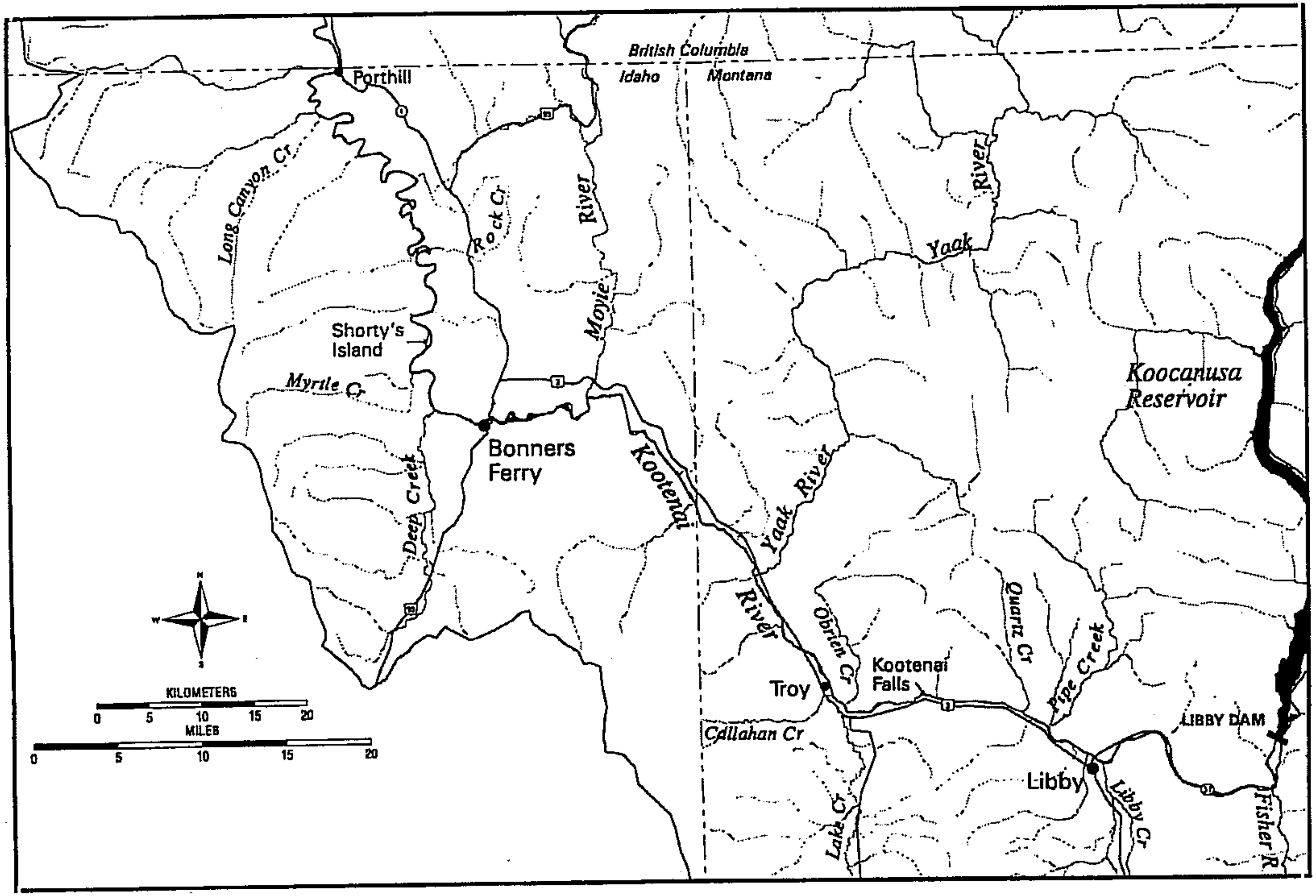

Figure 2. Map of the Kootenai River Basin in Idaho and Montana. Notable geographic features include Kootenai Falls, the suspected upstream migration barrier for white sturgeon, and the Kootenai River reach from Bonners Ferry downstream to Shorty's Island where white sturgeon spawning has been detected in recent years.

1983) to approximately 880 fish by 1990 (Apperson and Anders 1991). More recently, a refined white sturgeon population analysis using capture information collected from the Kootenai River and Kootenay Lake over a 4-year period estimated 1,468 adult fish (95 percent confidence interval: 740 to 2,197) and 87 wild juveniles. Although this revised estimated population is higher than the level when the white sturgeon was listed in 1994, the unbalanced population structure and primary factors affecting the listing decision persist.

The population is reproductively mature, with few of the remaining white sturgeon younger than 25 years old. The Idaho Department of Fish and Game (IDFG) estimated that 7 percent of female, and 30 percent of male white sturgeon in the Kootenai River were reproductively mature in any given year (Apperson 1992). Recent monitoring has documented an approximate 1.7:1 male to female ratio of adult fish (Paragamian et al. 1997).

The youngest white sturgeon collected in surveys since 1972 include representatives from 13 year classes (Paragamian et al. 1996, 1997). Captured fish include at least one fish hatched each year from 1972 through 1980; two fish hatched in1983 year; and at least nine, two, and one fish produced from the 1991, 1992, and 1995 year classes, respectively. Little is known about habitats used by juvenile white sturgeon in the Kootenai River basin.

Genetic analysis indicates that Kootenai River white sturgeon are a unique stock and constitute a distinct interbreeding population (Setter and Brannon 1990). The measure of genetic variation determined for the Kootenai River population is much lower compared to white sturgeon in the lower Columbia River (Setter and Brannon 1990). Based on these comparisons, Setter and Brannon (1990) concluded "...we find adequate evidence to distinguish these fish as a separate population...." This is consistent with the geographic isolation of the population since the last glacial age.

C. <u>Aquatic Community</u>

Fish community associates of the Kootenai River white sturgeon include the burbot (*Lota lota*) and several native salmonids: westslope cutthroat trout

(*Oncorhynchus clarki lewisi*), interior redband and rainbow trout (*Oncorhynchus mykiss gairdneri* and *O. m. irideus.*), bull trout (*Salvelinus confluentus*), kokanee, and mountain whitefish (*Prosopium williamsoni*) (Appendix A).

In general, fish populations have declined in the Kootenai River basin over the past several decades. Bull trout in the Kootenai River basin are part of the Columbia River population of bull trout listed as "threatened" in the United States under the Endangered Species Act on June 10, 1998 (63 FR 31647). Bull trout are now isolated into five subpopulations in the United States portion of the basin, with subpopulations generally with relatively low abundance. Kokanee populations have declined dramatically in the Kootenay Lake system since the 1970's. For example, kokanee runs into north Idaho tributaries of the Kootenai River numbering tens of thousands of fish as recently as the early 1980's (Partridge 1983) declined to only three fish in six of their historic spawning tributaries by 1997 (Sue Ireland, KTOI, pers. comm., 1998). Several factors are believed to have contributed to the kokanee collapse, primarily a decline in overall biological productivity due to Libby Dam construction and operations, and degraded spawning habitat. The introduction of mysid shrimp in Kootenay Lake, an efficient competitor with kokanee for food, has also contributed (Ashley and Thompson 1993). Additionally, catch rates of rainbow trout, and standing stock and growth rates of mountain whitefish in the Kootenai River have declined since the early 1980's (Paragamian 1994). The burbot population has also declined during recent decades, as indicated by an ongoing burbot population study in the Kootenai River and Kootenay Lake. The decline in burbot is not fully understood but is also thought to be partially due to the changing Kootenai River flow patterns during the winter burbot spawning period, and reduced biological productivity. Past overharvest of burbot in the Kootenai River and Kootenay Lake may also have reduced their population size (Paragamian and Whitman 1997).

D. Reasons for Decline

The significant change to the natural flows in the Kootenai River caused by flow regulation at Libby Dam is considered to be a primary reason for the Kootenai River white sturgeon's continuing lack of recruitment and declining numbers.

Beginning with the partial operation of Libby Dam in 1972 (though not fully operational until 1974), average spring peak flows in the Kootenai River have been reduced by more than 50 percent, and winter flows have increased by 300 percent compared to predam values (Figure 3). As a result of original Libby Dam operations until the initiation of experimental flows in 1992, the natural high spring flows thought to be required by white sturgeon for reproduction rarely occurred during the May to July spawning season when suitable temperature, water velocity, and photoperiod conditions would normally exist. In addition, cessation of periodic flushing flows has allowed fine sediments to build up in the Kootenai River bottom substrates. This sediment fills the spaces between riverbed cobbles, reducing fish egg survival, larval and juvenile fish security cover, and insect production.

Additionally, the elimination of side-channel slough habitats in the Kootenai River flood plain due to diking and bank stabilization to provide flood protection for agricultural land; development of Creston Valley Wildlife Management Area in British Columbia and Kootenai National Wildlife Refuge in Idaho; and lower Kootenay Lake spring maximum elevations are also a contributing factor to the white sturgeon decline. Much of the Kootenai River has been channelized and stabilized from Bonners Ferry downstream to Kootenay Lake resulting in reduced aquatic habitat diversity, altered flow conditions at potential spawning and nursery areas, and altered substrates in incubation and rearing habitats necessary for survival (Partridge 1983, Apperson and Anders, 1991).

As a consequence of altered flow patterns, average water temperatures in the Kootenai River are typically warmer (by 3 degrees Celsius; 37 degrees Fahrenheit) during the winter and colder (by 1 - 2 degrees Celsius; 34 - 36 degrees Fahrenheit) during the summer than prior to impoundment at Libby Dam (Partridge 1983). However, during large water releases and spills at Libby Dam in the spring, water temperatures in the Kootenai River may be colder than under normal nonspill spring flow conditions.

The overall biological productivity of the Kootenai River downstream of Libby Dam has been altered. Based on limnological studies of Kootenay Lake, Daley et al. (1981) concluded that the construction and operation of Libby Dam (and

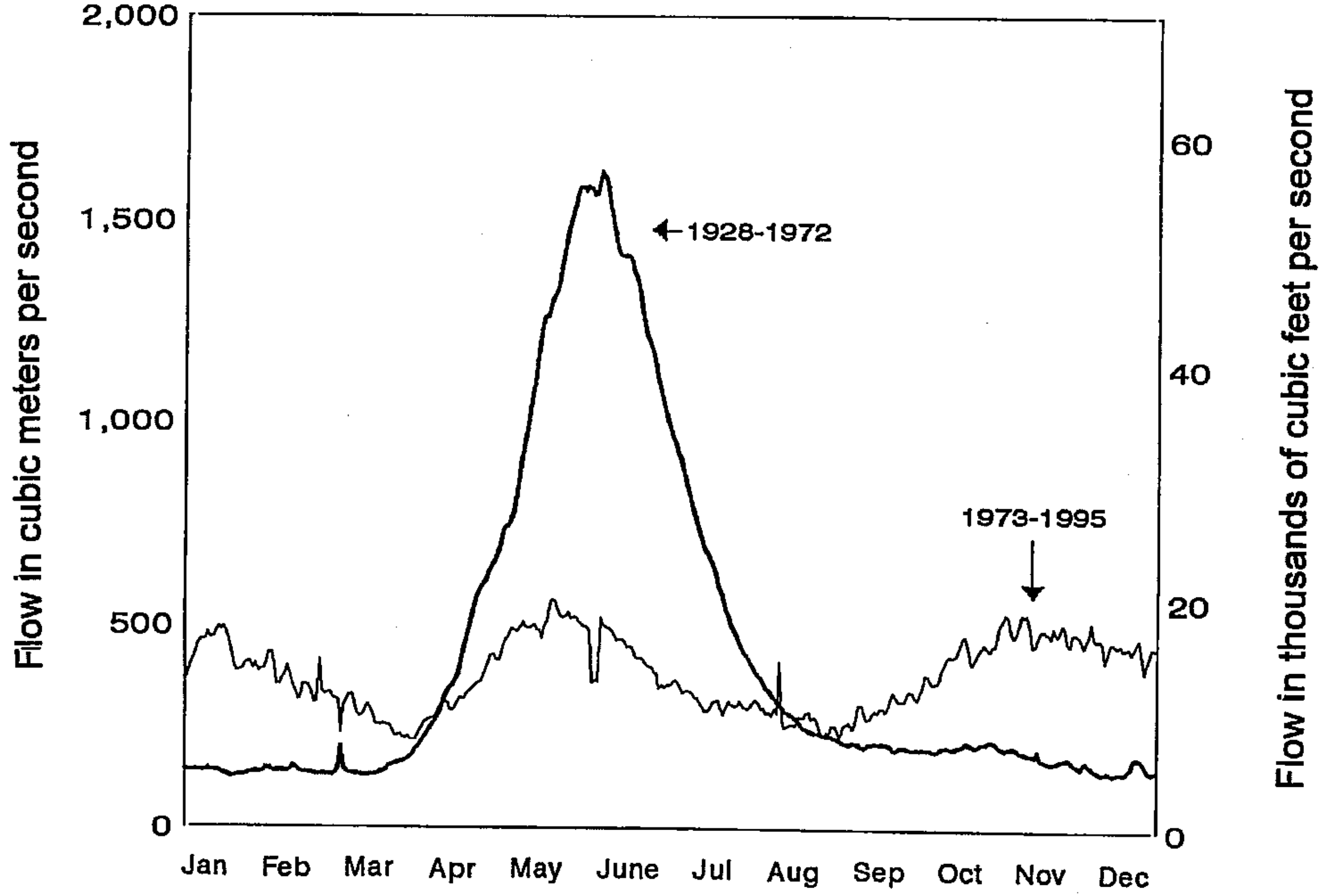

Figure 3. Mean monthly Kootenai River flows at Bonners Ferry for 1928–1972 (pre-Libby Dam) and 1973–1995 (post-Libby Dam) periods.

Duncan Dam, British Columbia) "...has drastically altered the annual hydrograph and has resulted in modifications to the quality of water now entering the lake by removing nutrients, by permitting the stripping of nutrients from the water in the river downstream from Libby Dam, and altering the time at which the nutrients are supplied to the lake." Potential threats to Kootenai River white sturgeon from declining biological productivity include decreased prey abundance and food availability for some life stages of sturgeon downstream of Libby Dam, and possible reduction in the overall capacity for the Kootenai River and Kootenay Lake to sustain substantial populations of white sturgeon and other native fishes. For example, total zooplankton densities in the Kootenai River at Bonners Ferry (mean fewer than 0.1 organism/liter) are lower than in other rivers of the northwestern United States (Paragamian 1994).

Poor water quality and excessive nutrients in the upper Kootenai River were considered to be major problems for the white sturgeon and other native fishes prior to the construction and operation of Libby Dam. Graham (1981) believed that poor water quality conditions in the 1950's and 1960's, from industrial and mine development, most likely affected white sturgeon reproduction and recruitment prior to 1974. Significant improvements in Kootenai River water quality were noted by 1977, due in part to waste water control and effluent recycling measures initiated in the late 1960's. Although fertilizer processing, sewage, lead-zinc mine, and vermiculite discharges have been eliminated, many of these pollutants and contaminants persist, primarily bound in sediments.

Apperson (1992) noted detectable levels of aluminum, copper, lead, zinc, and strontium, along with polychlorinated biphenyls (PCB) and pesticides, in white sturgeon egg samples from the Kootenai River. However, other than copper, detectable levels of these compounds, e.g. polychlorinated biphenyls, organochlorides, and zinc, were lower than levels found in other Columbia River basin white sturgeon that successfully reproduce. Ultimately, the overall effects of these pollutants on sturgeon reproduction and survival are unknown. Kootenai River white sturgeon eggs have been hatched under experimental hatchery conditions using both Kootenai River water and domestic city water, however the chronic effects of heavy metals on egg hatching success and the dietary pathways of larvae and young-of-the-year white sturgeon have not been investigated.

Georgi (1993) noted that the chronic effects on wild sturgeon spawning in "chemically polluted" water and rearing over contaminated sediments, in combination with bioaccumulation of contaminants in the food chain, is possibly reducing the successful reproduction and early-age recruitment to the Kootenai River white sturgeon population.

E. Conservation Measures

At present, there are several State, Federal, Tribal, and Canadian programs and conservation efforts that may help achieve recovery objectives for the Kootenai River population of white sturgeon. These measures are described below.

1. Kootenai River management activities

The following is a brief summary of the 1991 through 1997 flow releases for Kootenai River white sturgeon. These flows, considered experimental from 1991 through 1997 and concurrent monitoring of white sturgeon, were intended to identify some factors limiting successful reproduction of Kootenai River white sturgeon and help achieve recovery.

1991: In the spring of 1991, the United States Army Corps of Engineers (USACE) and Bonneville Power Administration managed flows for white sturgeon at the request of the Idaho Department of Fish and Game. Approximately 566 cubic meters per second (m^3/s) (20,000 cubic feet per second [cfs]) were released at Libby Dam for a 2 week interval during the spawning period. The Army Corps of Engineers operations provided flows of above 991 cubic meters per second (35,000 cubic feet per second) at Bonners Ferry for 15 days with water temperatures at 14 degrees Celsius (57 degrees Fahrenheit). A peak flow of 1,521 cubic meters per second (53,700 cubic feet per second) was recorded on May 19 at Porthill, Idaho. This was accomplished without storing additional water in Koocanusa Reservoir because of above normal water conditions in the Kootenai River basin. The combination of local runoff below Libby Dam and water released to meet flood control requirements provided the range of flows (Figure 4). On July 3, 13 white sturgeon eggs were collected within 100 meters (300 feet) down river from the railroad bridge at Bonners Ferry

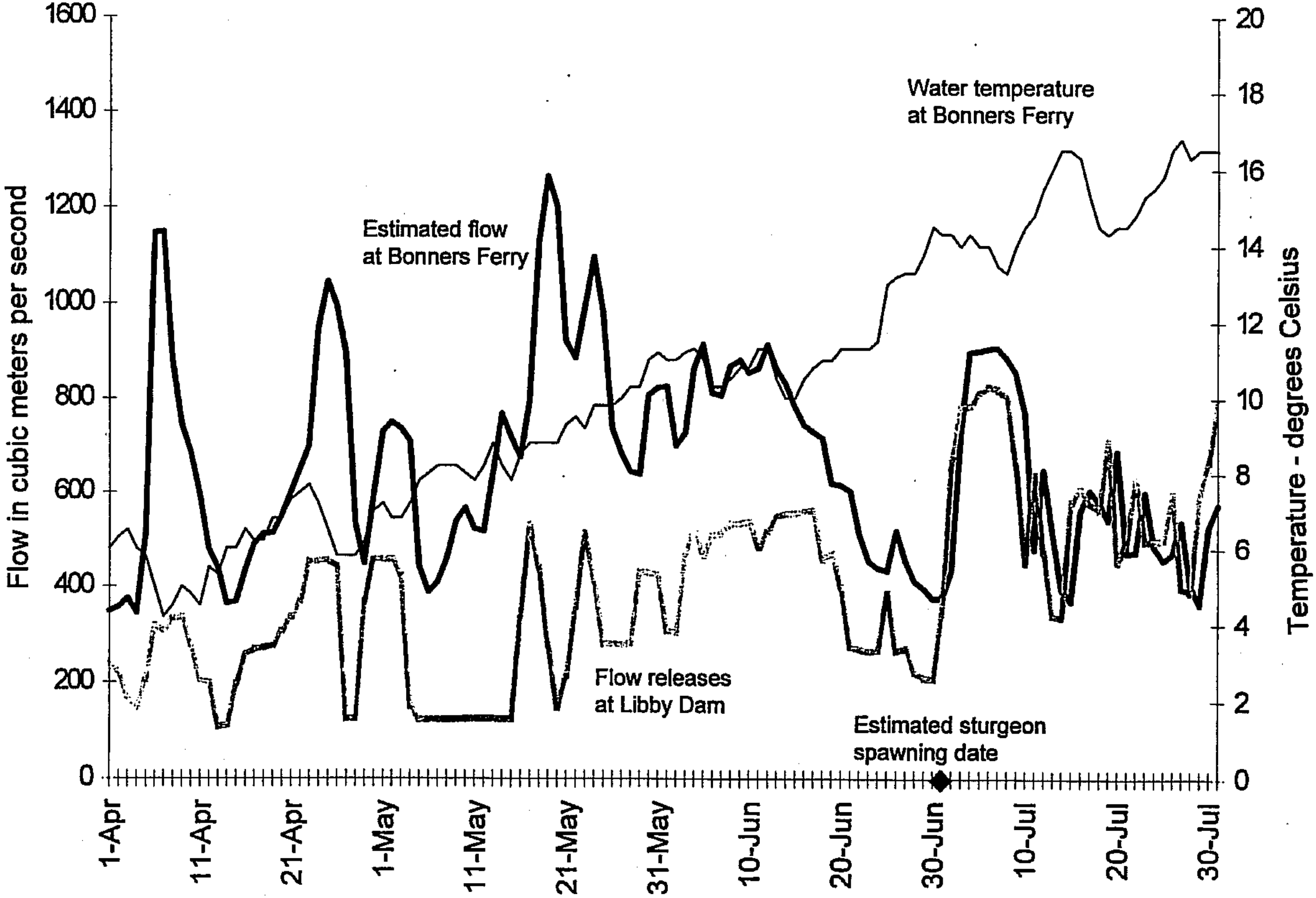

Figure 4. Kootenai River estimated flows and water temperature observed during April through July, 1991.

(river-kilometer 245, river-mile 153) (Apperson and Anders 1991). No larval white sturgeon were found in the Kootenai River in 1991. However, four juvenile white sturgeon aged to the 1991 year class have been found in subsequent sampling.

1992: The Bonneville Power Administration and the U.S. Army Corps of Engineers attempted to manage water releases similar to 1991 at the request of the Idaho Department of Fish and Game. However, because of the poor water year, water was not released for flood control during the white sturgeon spawning season (Figure 5). In June 1992, the Bonneville Power Administration was also requested by BC Hydro (supported by the Governor of Montana's concern for the health of the reservoir fishery) and the Army Corps of Engineers to store water in Koocanusa Reservoir for recreational purposes. As a result, flows dropped from nearly 566 to 113 cubic meters per second (20,000 to 4,000 cubic feet per second) in the Kootenai River during the critical white sturgeon spawning period. No white sturgeon eggs or larvae were found in the Kootenai River (Apperson and Wakkinen 1993).

1993: In an attempt to develop a regional prelisting recovery strategy for sturgeon that would form the basis of a conservation agreement between the U.S. Fish and Wildlife Service and various agencies, the Kootenai White Sturgeon Technical Committee (Technical Committee) was formed. The Committee comprised representatives from the U.S. Fish and Wildlife Service; Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; Kootenai Tribe of Idaho; Army Corps of Engineers; Bonneville Power Administration; and several other United States and Canadian agencies. Based upon recommendations by some Technical Committee members, the Fish and Wildlife Service requested flows of 991 cubic meters per second (35,000 cubic feet per second) for a 40-day period. The Army Corps of Engineers and Bonneville Power Administration were unable to implement the request because of operating constraints of the hydrosystem, but did store 493,413,000 cubic meters (400,000 acre-feet) of water in Koocanusa Reservoir for white sturgeon experimental flows. Water released provided 566 cubic meters per second (20,000 cubic feet per second) at Bonners Ferry from June 2 through June 16

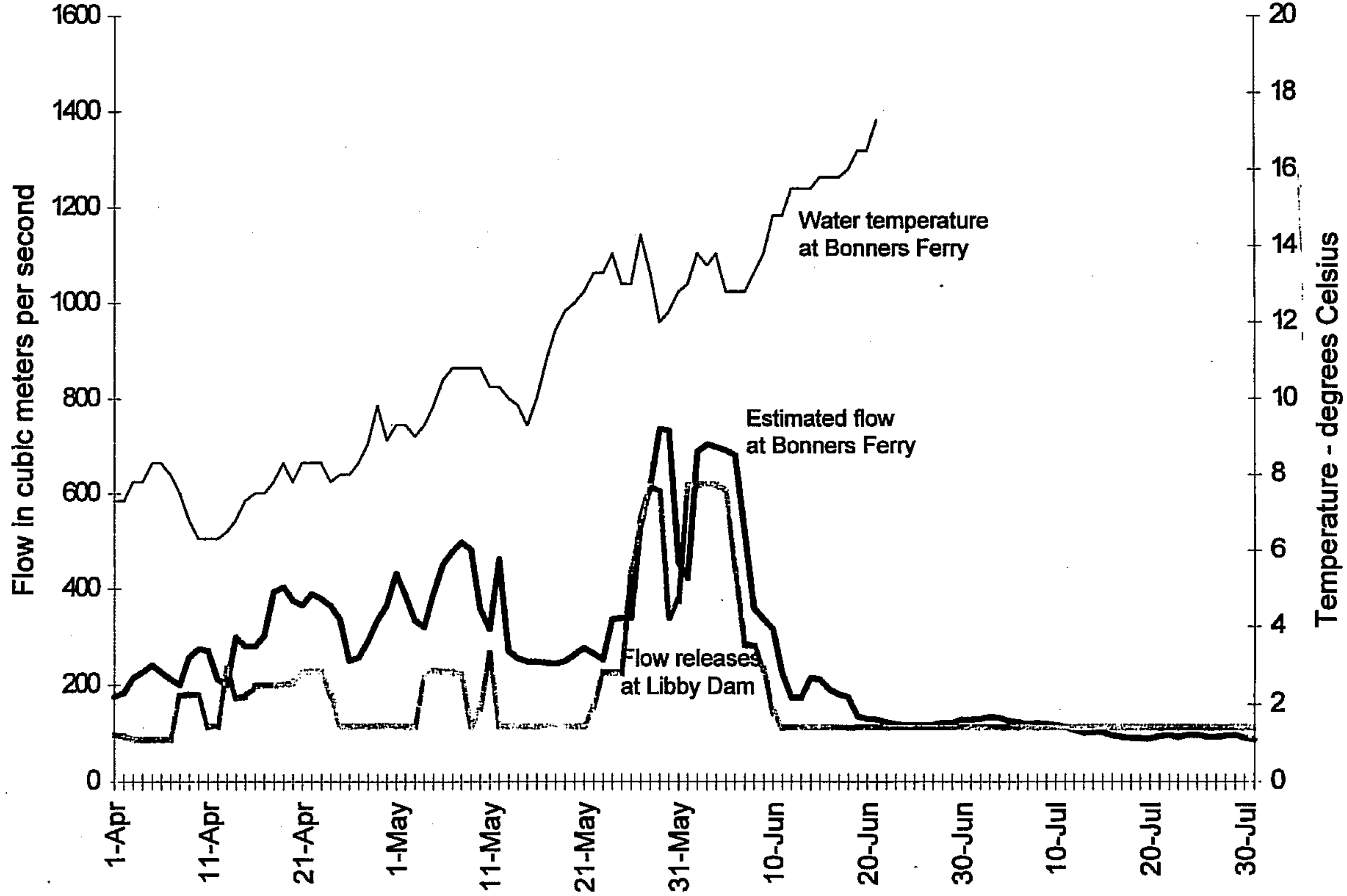

Figure 5. Kootenai River estimated flows and water temperature observed during April through July, [illegible]

(Figure 6). Three white sturgeon eggs (one fertilized, one dead, and one unfertilized) were collected in the Kootenai River near the US 95 Highway bridge at Bonners Ferry (river-kilometer 245, river-mile 153) when water temperatures were 12 degrees Celsius (48 degrees Fahrenheit). No larval white sturgeon were found (Marcuson 1994). To date, no 1993 year class juvenile white sturgeon have been found.

On July 7, 1993, the U.S. Fish and Wildlife Service proposed to list the Kootenai River population of white sturgeon as "endangered" under the Endangered Species Act.

1994: In July 1994, the Fish and Wildlife Service issued a formal Conference Opinion on the effects of the 1994-1998 Federal Columbia River Power System (FCRPS), concluding that the proposed operation was not likely to jeopardize the sturgeon. The action proposed by the Fish and Wildlife Service was in 3 out of 10 years to 1) maintain 425 cubic meters per second (15,000 cubic feet per second) at Bonners Ferry in May; 2) increase discharge from Libby Dam to provide 566 cubic meters per second (20,000 cubic feet per second) at Bonners Ferry for 35 days during the expected spawning season; 3) ramp down and maintain 312 cubic meters per second (11,000 cubic feet per second) for 28 days at Bonners Ferry; and 4) keep flow releases constant during May through July in years when flows were provided. This action could also benefit listed salmon species in the lower Columbia River drainage.

During the 1994 runoff period, the Bonneville Power Administration and the Army Corps of Engineers stored 1,480,000,000 cubic meters (1,200,000 acre-feet) of water behind Libby Dam as part of a flow augmentation program. This water was released to stimulate natural spawning of white sturgeon (Figure 7). Flow at Bonners Ferry was held above 425 cubic meters per second (15,000 cubic feet per second) during May and was increased to 566 cubic meters per second (20,000 cubic feet per second) on June 1 and maintained for 28 days. Flow was then decreased over 3 days to 340 cubic meters per second (12,000 cubic feet per second) by July 2, and held stable over the July 4 weekend at the request of the State of Montana to benefit recreation. Libby Dam discharge was then ramped down over 5 days to 113 cubic meters per second (4,000 cubic feet per second) by

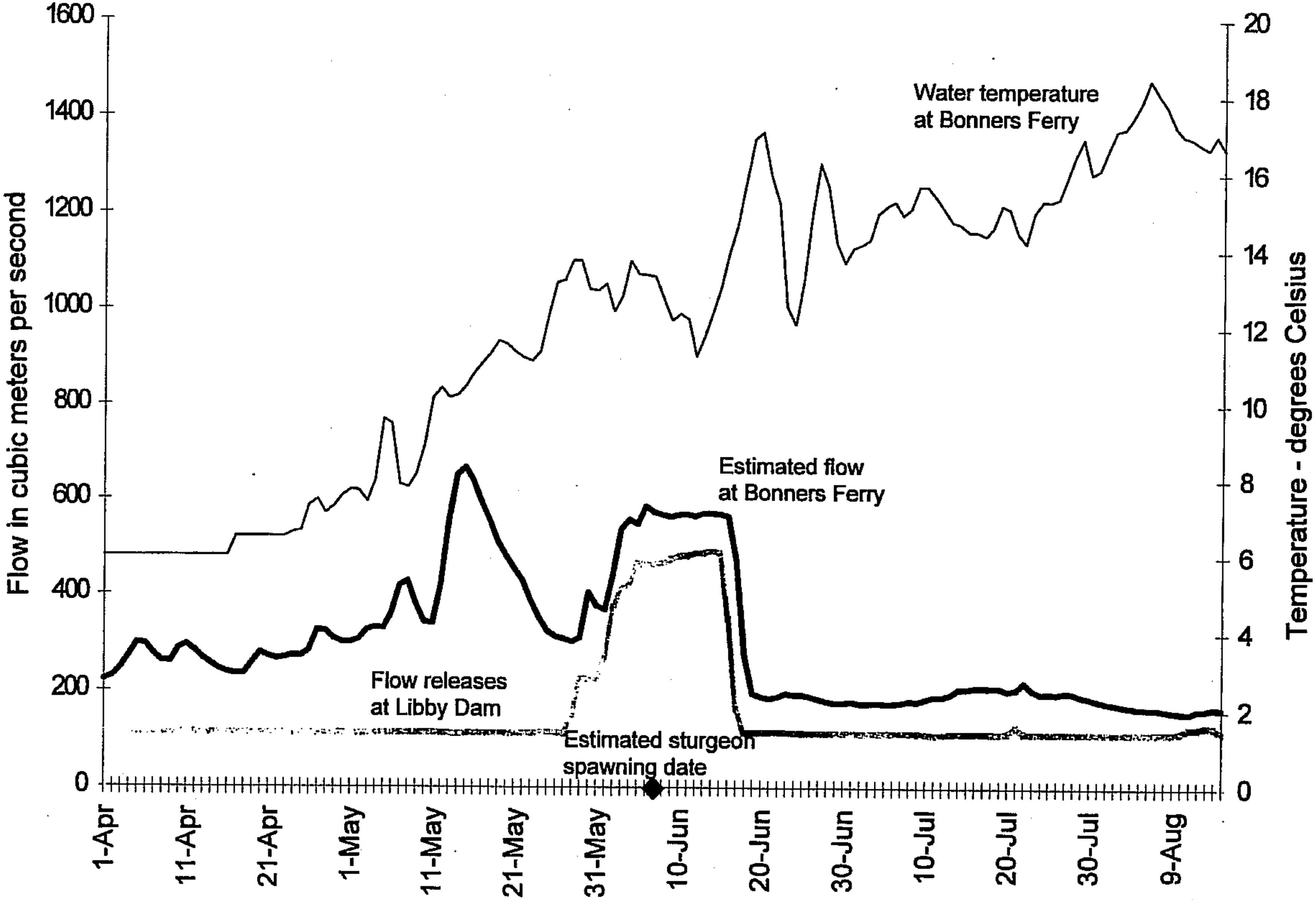

Figure 6. Kootenai River estimated flows and water temperature observed during April through July, 1993.

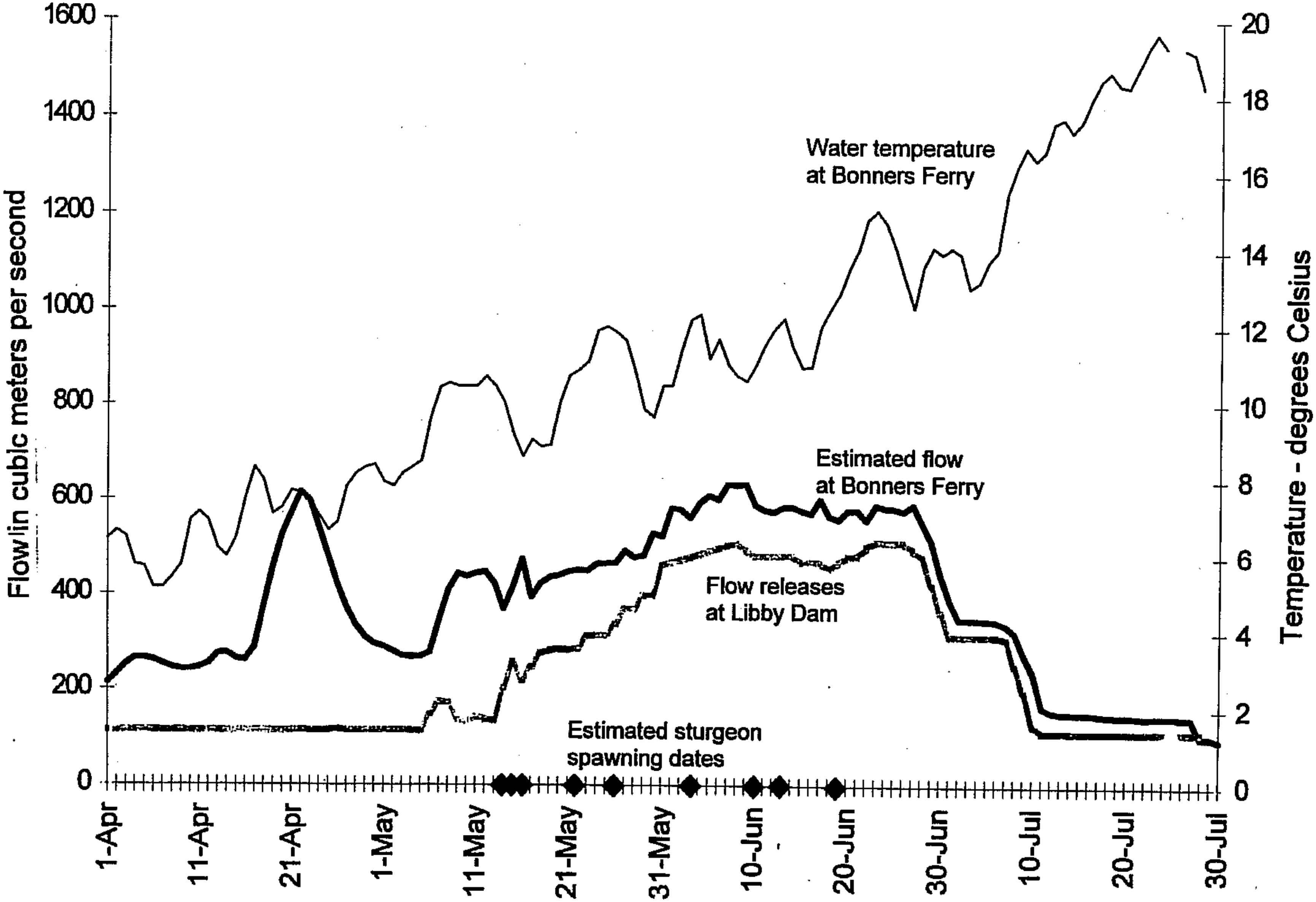

Figure 7. Kootenai River estimated flows and water temperature observed during April through July, 1994.

July 11, when the 1,480,000,000 cubic meters (1,200,000 acre-feet) of stored water was exhausted. A total of 213 white sturgeon eggs were collected over 19 days beginning May 15 through June 20 near Shorty's Island (river-kilometers 228.7 - 230.9; river-miles 143 - 144) and between Myrtle and Deep Creeks (river-kilometer 237.5; river-mile 147) (Kootenai Tribe et al. 1995). No live larval white sturgeon were found in the wild during 1994, however, one newly emerged larva was found in a largescale sucker stomach in early June.

The Kootenai River population of white sturgeon was listed as endangered under the Act on September 6, 1994. In the final rule the Fish and Wildlife Service stated "that there is no recent evidence of successful spawning and survival past the egg stage" and "...existing regulations and experimental flow programs have not been effective in arresting..." the decline of the species.

1995: On December 15, 1994, the Federal Columbia River Power System action agencies submitted a supplement to the 1994-1998 Biological Assessment (B.A.) to the Fish and Wildlife Service (see previous "1994" discussion). The supplement to the Biological Assessment addressed future operation of the Federal Columbia River Power System and potential impacts upon listed species. Beginning in mid-December, the Fish and Wildlife Service, National Marine Fisheries Service (NMFS), and the action agencies (the Bonneville Power Administration, Army Corps of Engineers, and the Bureau of Reclamation [BR]) formally consulted during a series of meetings and information exchanges. The Fish and Wildlife Service and the action agencies considered how the proposal to operate the Federal Columbia River Power System as described in the Supplemental Biological Opinion could avoid jeopardy to the Kootenai River white sturgeon. To consider all viewpoints, the Fish and Wildlife Service solicited comment on the January 25, 1995, draft Biological Opinion from affected State and Tribal management agencies. On March 1, 1995, the Fish and Wildlife Service issued a final Biological Opinion addressing the effects of Federal Columbia River Power System operations in 1995 and future years on the Kootenai River white sturgeon.

The final Biological Opinion described reasonable and prudent alternatives to regulate flows at Libby Dam for 1995 to 1998. Regulation of flows must be consistent with existing treaties and laws, e.g. the International Joint Commission and the Columbia River Treaty. Operations for 1995 were more limited than those described for 1996 to 1998 because only four of the five turbines in Libby Dam were functional.

The 1995 flow augmentation program (Figure 8) was implemented as follows: Approximately 2,467,000,000 cubic meters (2 million acre-feet) of water were stored in Koocanusa Reservoir to benefit white sturgeon. Increased flows began on April 29 to achieve 433 cubic meters per second (15,300 cubic feet per second) at Bonners Ferry on May 2. Flows ranged from 425 to 482 cubic meters per second (15,000 to 17,000 cubic feet) until May 15, when Libby Dam discharge increased to about 566 cubic meters per second (20,000 cubic feet per second) by May 16, allowing local inflow to vary Bonners Ferry flows while Libby outflow was held steady. Water temperatures remained below the optimal range for white sturgeon during most of the flow augmentation period. Bonners Ferry flows ranged from 765 to 1,076 cubic meters per second (27,000 to 38,000 cubic feet per second) during this period, which ended June 26. Flows were gradually decreased to minimum Libby Dam discharge of 113 cubic meters per second (4,000 cubic feet per second) by July 22; Bonners Ferry flow was 272 cubic meters per second (9,600 cubic feet per second). Flows were again increased on July 29, reaching about 437 cubic meters per second (16,000 cubic feet per second) by August 1, primarily to benefit salmon downstream in the Columbia River. On August 10, Kootenai River flows at Bonners Ferry reached 453 cubic meters per second (16,600 cubic feet), with very low local inflows. This second peak during the normally warm summer months departs from the natural hydrograph and can cause stranding of aquatic insects and fish eggs and larvae. Similar to 1994, 163 white sturgeon eggs were recovered only near Shorty's Island at approximately 12 river-kilometer (7.5 river-mile), downstream of Bonners Ferry, and were not recovered in the river near Bonners Ferry (Anders and Westerhof 1996). Most of the fertilized eggs were less than 60 hours old and no larvae or juvenile white sturgeon from the 1995 year class have been found through March 1996.

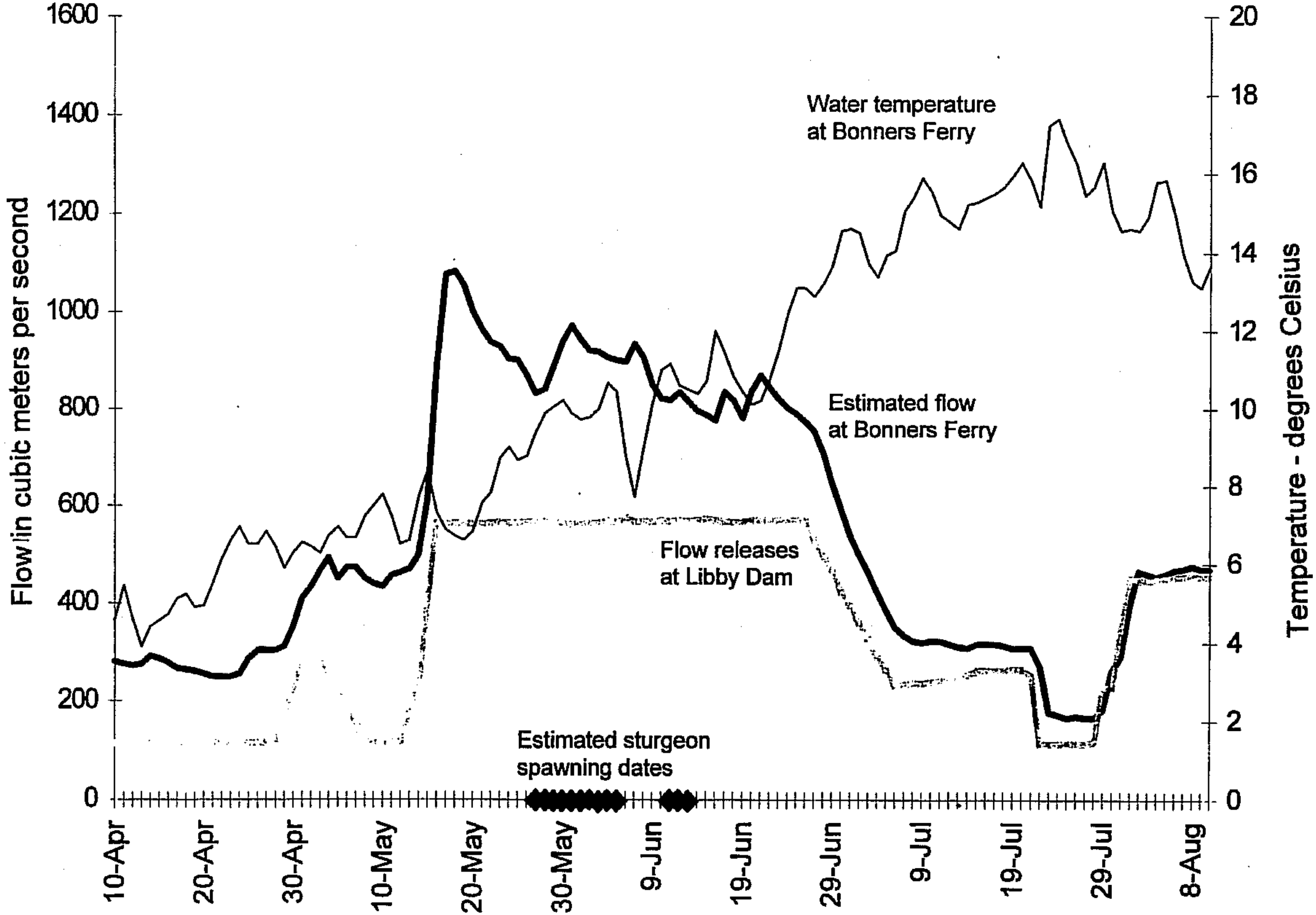

Figure 8. Kootenai River estimated flows and water temperature observed during April through July, 1995.

1996: Temperatures in the Kootenai River at Bonners Ferry reached an early though brief level of nearly 8 degrees Celsius (46 degrees Fahrenheit) in mid-April, and Libby Dam discharges were increased from base levels to about 650 cubic meters per second (23,000 cubic feet per second) by April 13. This level was held until about April 25, and lowland runoff complemented it, reaching peaks at Bonners Ferry of about 1,200 cubic meters per second (42,000 cubic feet per second) and 1,350 cubic meters per second (48,000 cubic feet per second) during that time (Figure 9). Lowland runoff tailed off while Libby discharge was dropped to a level of 263 cubic meters per second (9,300 cubic feet per second) by about May 1. In mid-May, lowland runoff again increased, and Libby discharges also increased in response to increasing inflows from higher elevations. A series of peaks as high as 1,400 cubic meters per second (49,500 cubic feet per second) occurred by early June at Bonners Ferry as water temperatures there exceeded 7 degrees Celsius (44 degrees Fahrenheit) and dam discharges were increased to stimulate sturgeon migration and spawning. Water temperatures reached 8 degrees Celsius (46 degrees Fahrenheit) by the end of May, and 9 degrees Celsius (48 degrees Fahrenheit) by early June. Local runoff declined starting in early June, and by the end of June was only about 300 cubic meters per second (10,600 cubic feet per second). By mid-July it was well under 100 cubic meters per second (3,500 cubic feet per second). Libby discharges were gradually dropped, but with peaks added above 700 cubic meters per second (24,700 cubic feet per second) in early and mid-July to further stimulate sturgeon reproductive activity, coinciding with temperatures of 12 degrees Celsius (54 degrees Fahrenheit), and 14 degrees Celsius (58 degrees Fahrenheit) respectively. In 1996, a total of 349 eggs were collected between June 8 and June 30. No white sturgeon larvae were collected in 1996.

1997: The Kootenai River at Bonners Ferry rose above 1,414 cubic meters per second (50,000 cubic feet per second) during 1997. Exceptionally heavy precipitation and 130 percent greater than average snow pack in the drainage raised flows at Bonners Ferry to over 1,526 cubic meters per second (54,000 cubic feet per second) during April and May (Figure 10). The peak flow for 1997 reached 1,547 cubic meters per second (54,600 cubic feet per second) on May 14. Most of the flow in April and May was local inflow. As a consequence, water management at Libby Dam was primarily for flood control at Bonners Ferry and

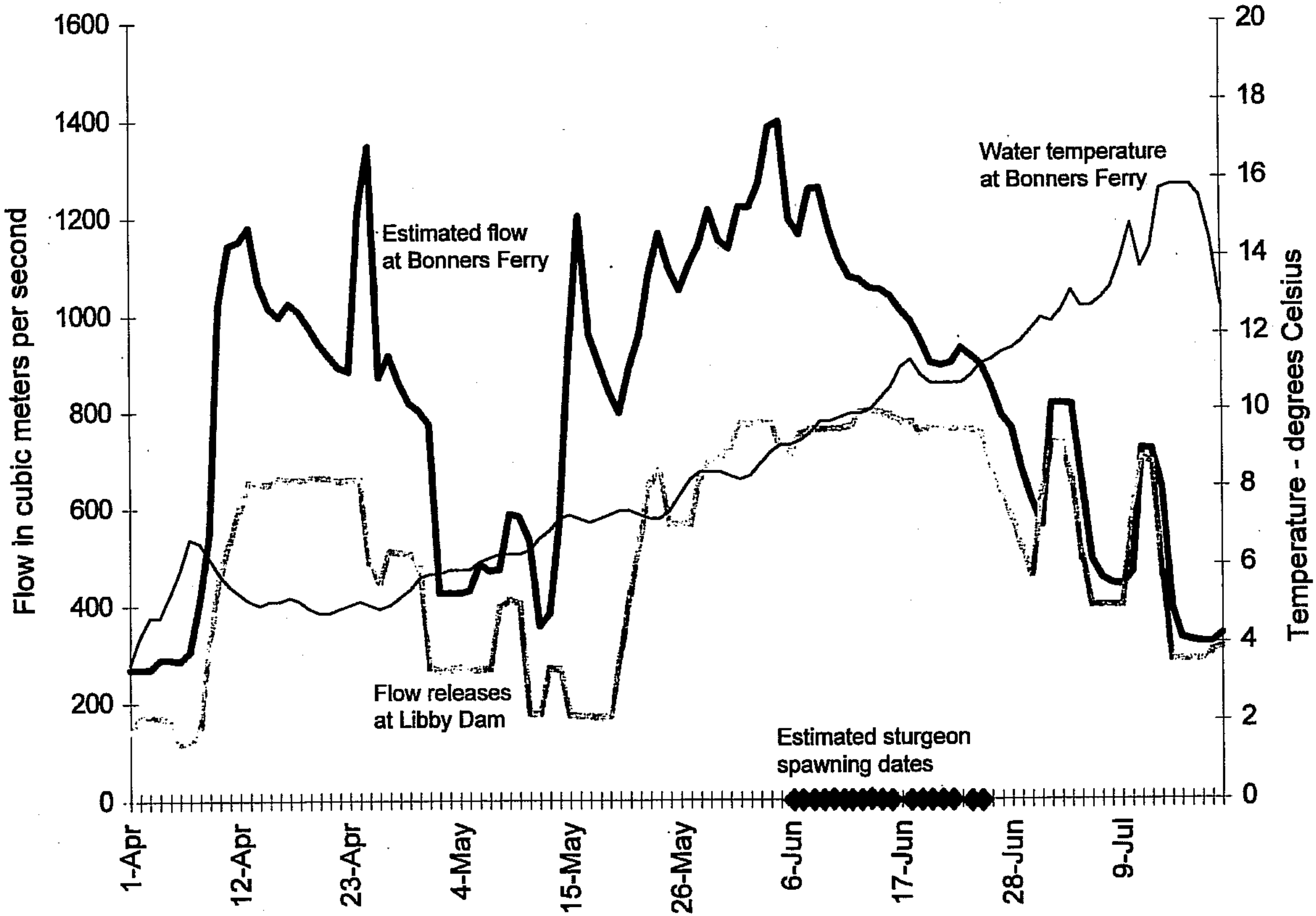

Figure 9. Kootenai River estimated flows and water temperature observed during April

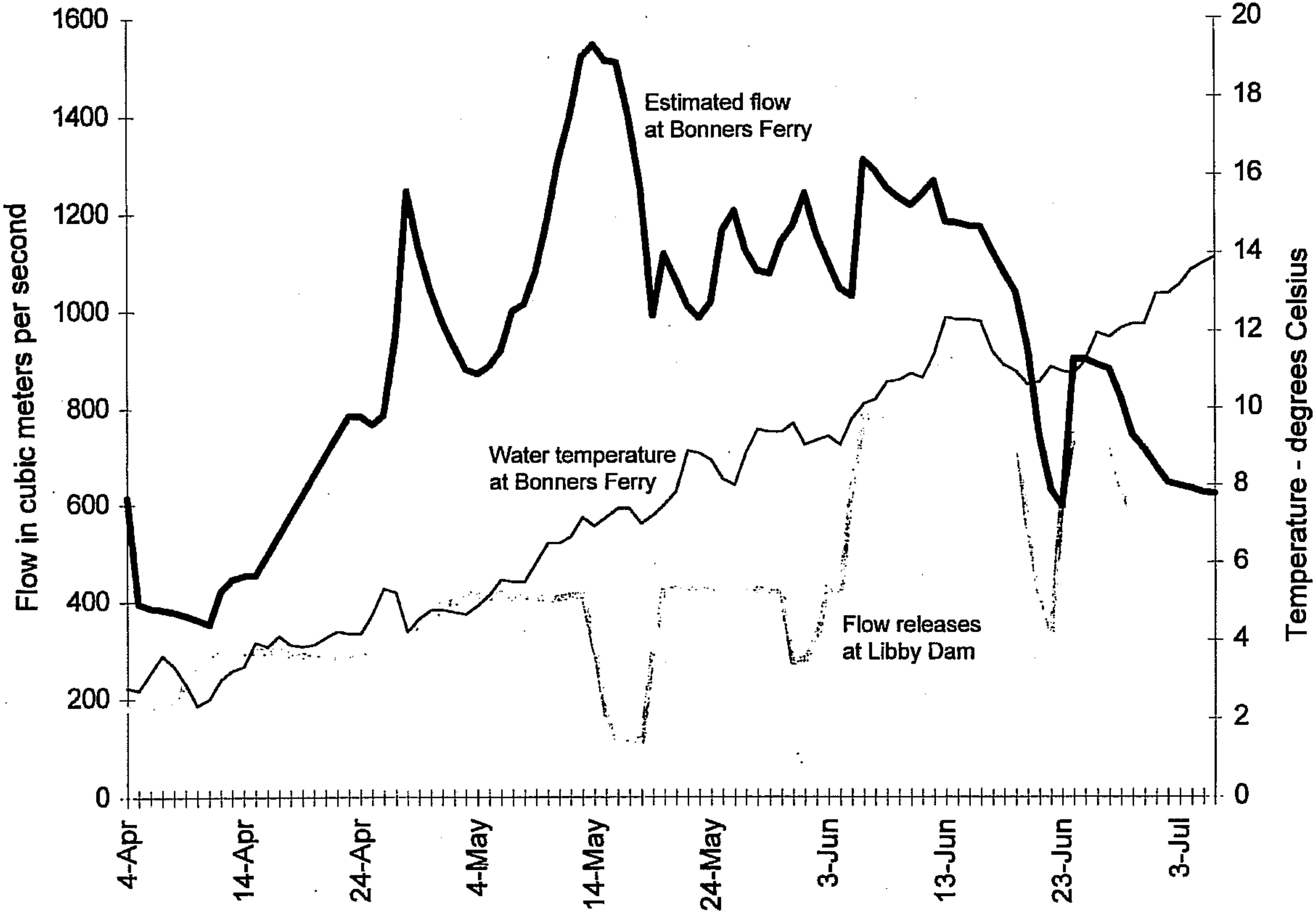

Figure 10. Kootenai River estimated flows and water temperature observed during April through July, 1997.

the Kootenai River valley. Discharge from Libby Dam was held to only 162 to 354 cubic meters per second (5,700 to 12,500 cubic feet per second) for the entire month of April. Despite these efforts, near flood conditions still prevailed in the lower portion of the drainage because of the volume of local inflow. Test flows were initiated on June 5; flows reached 1,320 cubic meters per second (46,600 cubic feet per second) on June 6. Temperature rose from about 9.1 degrees Celsius (48 degrees Fahrenheit) on June 4 to 10.1 degrees Celsius (50.2 degrees Fahrenheit) on June 6. The first test ended when flows at Bonners Ferry were reduced slightly to 1,220 cubic meters per second (43,000 cubic feet per second) by June 10 and then increased with augmented flows from Libby Dam to produce 1,270 cubic meters per second (44,700 cubic feet per second) by June 12 at Bonners Ferry, which was the beginning of the second test. Temperature during the second flow test increased from 10.1 degrees Celsius (50.2 degrees Fahrenheit) to 11.4 degrees Celsius (52.5 degrees Fahrenheit) on June 12. Following ramp down on June 13, the temperature increased to 12.3 degrees Celsius (54.1 degrees Fahrenheit) for 3 days. Flows were gradually ramped down after the second test and were as low as 357 cubic meters per second (12,6000 cubic feet per second) by the end of July. A total of 75 eggs were collected between June 5 and June 24. One larval white sturgeon was collected in the Kootenai River near Myrtle Creek at river-kilometer 236 (river-mile 145).

2. Columbia River Basin Fish and Wildlife Program

The Northwest Power Act of 1980 authorized the States of Idaho, Montana, Oregon, and Washington to create a policy-making and planning body for electrical power and the Columbia River basin's fish and wildlife resources (Northwest Power Planning Council 1987). The Northwest Power Planning Council (NPPC) was created in 1980 to develop the Columbia River Basin Fish and Wildlife Program (Program). The Program was intended to protect, mitigate, and enhance fish and wildlife resources affected by hydroelectric development in the Columbia River basin in the United States. In 1987 and 1994, the Program was amended to address several issues of concern in the Kootenai River drainage (NPPC 1987, 1994). The Bonneville Power Administration, the Army Corps of Engineers, the Bureau of Reclamation, and the Federal Energy Regulatory Commission are the Federal agencies responsible for implementing the Program.

The 1987 Program directed the Bonneville Power Administration to fund the following efforts related to the Kootenai River system:

1) Evaluate the effect of Libby Dam operations on reproduction and rearing of white sturgeon in the Kootenai River. Section 903(b)(1)C.

2) Develop operating procedures for Libby Dam to ensure that sufficient flows are provided to protect resident fish in the Kootenai River and Lake Koocanusa. Section 903(a)(5). Consult with the State of Montana if a conflict occurs between meeting minimum flows in Section 903(a)(5) and maintaining reservoir levels required by Section 903(b)(1).

3) Determine the impact of development and operation of the hydropower system on white sturgeon in the Columbia River basin. Section 903(e)(1).

4) Increase the number of rainbow trout, burbot (ling), and white sturgeon in the Kootenai River. Section 903(e)(7).

5) Design, construct, operate, and maintain a low-capital white sturgeon hatchery on the Kootenai Indian Reservation. Explore alternative ways to make effective use of the hatchery year-round. Section 903(g)(1)(H).

6) Survey the Kootenai River downstream of Bonners Ferry to the United States/Canada border to evaluate the effectiveness of the hatchery and assess the impacts of water fluctuations caused by Libby Dam on hatchery outplanting of white sturgeon in the Idaho portion of the Kootenai River. Section 903(G)(1)G.

The 1994 Program amendments called for the Bonneville Power Administration to continue to fund several of the 1987 measures for the Kootenai River drainage described above, and added several additional measures including:

1) Develop operating procedures for Libby Dam to ensure that sufficient flows are provided to protect resident fish. Section 10.3(B)(1).

2) Implement the Integrated Rule Curves (IRCs) for Koocanusa Reservoir; refine integrated rule curves to limit Koocanusa Reservoir drawdown to protect resident fish; and review State and Tribal recommendations on the biological effectiveness of the Integrated Rule Curves. Section's 10.3(B)(2,3,4).

3) Fund studies to evaluate the effect of Libby Dam operations on resident fish. Section 10.3(B)(5).

4) Design, construct, operate, and maintain mitigation projects in the Kootenai River system and Koocanusa Reservoir to supplement natural propagation of fish. Section 10.3(B)(11).

5) Operate and maintain a low-capital white sturgeon hatchery by the Kootenai Tribe of Idaho (KTOI). Section 10.4(B)(1).

6) Release water from Libby Dam to augment river discharge during the May through July sturgeon spawning period. Section 10.4(B)(3).

7) Restore white sturgeon and burbot populations in the Kootenai River. Section 10.6(C)(1).

3. Kootenai River white sturgeon research and monitoring

Research on white sturgeon in the Kootenai River basin by the Idaho Department of Fish and Game began in 1978 and continued through 1982. Study results indicated that white sturgeon recruitment began to decline in the mid 1960's, and that the general lack of recruitment was most pronounced after the construction of Libby Dam in 1972. White sturgeon research and monitoring in the Kootenai River basin resumed in 1988 based on the Northwest Power Planning Council's

1987 Fish and Wildlife Program (described in 2 above). These studies are funded by the Bonneville Power Administration in an effort to identify environmental factors limiting the white sturgeon population, and to recommend appropriate conservation and management actions to restore the wild white sturgeon population. The research and monitoring program has expanded in recent years with Bonneville Power Administration funding additional monitoring efforts by Montana Department of Fish, Wildlife, and Parks; Kootenai Tribe of Idaho; and British Columbia Ministry of Environment, Lands, and Parks, in addition to efforts by Idaho Department of Fish and Game. Much of the information generated from these studies was used by the Fish and Wildlife Service in the original listing determination and by the recovery team in developing this final recovery plan.

4. Kootenai Tribe of Idaho White Sturgeon Hatchery

The Kootenai Tribe of Idaho white sturgeon hatchery began as an experimental program in 1990 in response to questions concerning water quality, white sturgeon gamete viability, and feasibility of aquaculture as a component in recovery. Culture efforts first documented successful egg fertilization, incubation, egg viability, and juvenile white sturgeon survival (Apperson and Anders 1991). In 1991, 1992, 1993, and 1995, progeny from wild adult white sturgeon were successfully hatched and reared in the hatchery. The release of 305 hatchery reared age-1 and age-2 fish in 1992 and 1994 provided the first habitat use, movement, survival, and growth information for juvenile white sturgeon in the Kootenai River system. Subsequent monitoring results indicate that survival of these released fish is high and growth normal. In April and October 1997, 2,283 juvenile white sturgeon from the 1995 year class were released into the Kootenai River. Target release numbers for the conservation aquaculture program will be adjusted as more information on survival of hatchery reared juveniles becomes available.

5. Kootenai River Aquatic Investigations

Several studies authorized for the Kootenai River under the Program (as summarized in Conservation Measure #2) have been initiated or completed since

1983. These studies include:

Burbot and Rainbow Trout and Fisheries Inventory: Idaho Department of Fish and Game began the study in 1993 with the objectives to (1) identify factors that are limiting populations of burbot, rainbow trout, and other fish populations within the Kootenai River drainage in Idaho and British Columbia, and recommend management alternatives to restore the fishery to sustainable levels; and (2) determine if the burbot population is being limited by reproductive success, survival, and/or the recruitment of young burbot. Mitochondrial DNA analysis has indicated there may be two or more stocks of burbot in the Kootenai River basin (Paragamian et al. *in press*). Haplotypes from burbot collected from the Idaho and British Columbia reach of the Kootenai River were significantly different from burbot captured from two other locations within the Kootenai River drainage in Montana. A Kootenai River burbot recovery committee was formed during the spring of 1998 to devise methods and programs to restore this population.

Kootenai River Sediment and Water Quality Investigation: In 1995, the Kootenai Tribe of Idaho completed a 15-month investigation to determine if heavy metal pollutants from past mining, fertilizer production, and industrial and agricultural uses were present in the Kootenai River water column and river bed sediments. Eight sites were sampled monthly from Eureka, Montana downstream to Porthill, Idaho. Water and sediment samples were analyzed for arsenic, copper, lead, chromium, zinc, iron, mercury, selenium, and manganese. Analytical results from the water samples indicated the following pollutants violate Environmental Protection Agency aquatic criteria at several sites: mercury, lead, and selenium. Arsenic, copper, and lead were also found in river sediments. Preliminary study results concluded that at various sites, the river bottom is moderately polluted. The study has been funded for an additional 5 years to continue investigations of the biological, chemical, and limnological characteristics of the Kootenai River.

Kootenai River Ecosystem and Fishery Improvement Study: Beginning in 1995, the Kootenai Tribe of Idaho was contracted by Bonneville Power Administration to describe the existing biological community and nutrient availability in the Kootenai River. The study results will include an evaluation on the possible effects of Libby Dam operations on the biotic community and water quality, as well as remedies for any problems identified.

Ecosystem Metabolism and Nutrient Dynamics: In 1996, Idaho State University completed a comprehensive nutrient study funded by the Bonneville Power Administration for the Kootenai River in relation to flow enhancement. Study results revealed that Lake Koocanusa retained approximately 63 percent of its total phosphorus and 25 percent of its total nitrogen loading. Thus, the reservoir acts as a nutrient sink and the river downstream is nutrient deprived. Lake Koocanusa does not appear to chemically stratify. Thus, selective withdrawal from areas of nutrient concentrations is not currently possible. An energy budget developed for the river basin indicated that during most sampling periods, the river was dependent upon sources of energy other than that supplied directly by within-reach autotrophic productivity. Further analysis indicated that macroinvertebrates were not energy (food) limited.

Instream Flow Incremental Methodology study: A study to determine white sturgeon habitat availability in the Kootenai River downstream of Libby Dam under various flow regimes is being conducted by the Montana Department of Fish, Wildlife, and Parks. Microhabitat investigations will be completed during 1998. Model analyses have begun and results specific to white sturgeon and associated prey organisms will be available in 1999.

Kootenai Basin Trout Genetic Analysis: Recent genetic analysis of trout species inhabiting the Kootenai River drainage indicates that interior redband trout, westslope cutthroat, and bull trout were native species in portions of the Kootenai drainage prior to development (Huston 1995). Interior redband trout still exist in the drainage, and are genetically distinct from Gerrard rainbow trout native to Kootenay Lake. Prior to Huston's genetic assessment, it was believed that interior redband were native only in areas downstream of Kootenai Falls (Sage et al. 1992; Behnke 1992). Populations of genetically pure redband trout were located in the Yaak River drainage and upstream of Kootenai Falls. Additional sampling is presently underway to establish the range of interior redband trout in the Kootenai River drainage upstream of Kootenai Falls.

6. Kootenay Lake Fertilization Experiments

The British Columbia Ministry of Environment, Lands, and Parks and BC Hydro are currently fertilizing the North Arm of Kootenay Lake to increase biological productivity and restore native fish populations (Ashley and Thompson 1993). This program was initiated in 1992 in response to a long-term decline in the kokanee population, especially stocks from the North Arm of Kootenay Lake. These declines raised concerns for the future of the Kootenay Lake sport fishery, dominated by the Gerrard rainbow trout. Conversely, increasing overall biological productivity in Kootenay Lake should benefit white sturgeon by increasing a potential prey base.

The project involves releasing liquid fertilizer into a 16-kilometer (10-mile) zone of the North Arm of Kootenay Lake once per week from late April through early September. The fertilizer formulation is a blend of ammonium polyphosphate (10-34-0) and urea-ammonium nitrate (28-0-0). Approximately 317 tons of 10-34-0 and 581 tons of 28-0-0 are released each year during the application period, which is the equivalent of 70 percent of preimpoundment (1949) loading levels. As of early 1997, physical limnology parameters such as temperature, dissolved oxygen, pH, Redox potential, and water clarity have not changed significantly. However, total phosphorus concentrations have increased to preimpoundment levels, which is the target for the fertilizer loadings. Additionally, algal biomass levels in the fertilized area have increased similarly. Both mysid shrimp and kokanee abundance have increased. To date, the number of kokanee spawners in two tributaries of the North Arm (Meadow Creek and Lardeau River) have ranged from a low of 300,000 in 1991 to 1.5 million in 1997.

7. Harvest Regulations

There is no legal fishing for white sturgeon within the Kootenai River drainage in either the United States or Canada (Table 1).

Table 1. Summary of historical harvest regulations for white sturgeon within the Kootenai River drainage in the United States and Canada.

Year	Idaho	Montana	British Columbia
1944	two in possession; no yearly limit; no commercial harvest		
1948	one setline; one in possession		
1949	one setline; one in possession; 76 centimeters minimum size		
1952			setlines permitted; one per day; 92 centimeters minimum size
1955	one setline; one in possession; 102 centimeters minimum size		
1957	one setline; two per year; 102 centimeters minimum size	setlines permitted for burbot only	
1960	one setline; two per year; one in possession; 92 - 183 centimeters length restriction		
1968		setline permitted for sturgeon February 15 through June 30	

Year	Idaho	Montana	British Columbia
1973		six setlines with six hooks/ line, season Feb 15 to June 30; two per year; 102 - 183 centimeters in length	
1975		no setlines permitted; two per year; 102 - 183 centimeters length restriction	
1978			100 centimeters minimum size
1979	two per year; one in possession; 92 - 183 centimeters length restriction; permit required	all fishing prohibited	
1981			one per year; 100 centimeter minimum size
1982			sturgeon declared a sport fish
1983	setlines prohibited; July 1 to December 31; one per year; 92 - 183 centimeters length restriction		
1984	catch and release only; open all year		
1989			setlines prohibited
1990			catch and release only
1994	fishing prohibited		fishing prohibited

8. Libby Reservoir Modeling

A computer model was developed by the Montana Department of Fish, Wildlife, and Parks to assess the effects of Libby Dam operations on the biota in Koocanusa Reservoir (Marotz et al. 1996). The model design was based on empirical data (field collections) from 1982 to 1995. Model components representing the physical environment and biological trophic levels were calibrated separately to assure reliable output. Model studies were used to develop Integrated Rule Curves (IRC) for Libby Dam operation. The Integrated Rule Curves contain variable reservoir drawdown and refill targets dependent on monthly inflow forecasts. Reservoir elevations and dam discharges resulting from the Integrated Rule Curves are designed to balance the many demands on Kootenai River drainage waters (including sturgeon recovery measures) with fisheries in the headwaters and salmon recovery actions in the lower Columbia River system, power production, and flood control. One aspect of the Integrated Rule Curves concept contains "tiered" water releases to simulate a natural spring runoff event to aid white sturgeon spawning and rearing. The amount of flow augmentation is proportional to water availability (drought to flood) in a given year. Water stored for later release improves annual reservoir refill probability.

9. Kootenai River Model

In 1997, through a series of workshops, an Adaptive Environmental Assessment (AEA) model for the Kootenai River was developed as part of an adaptive management process to examine the potential benefits and impacts of alternate flow regimes from Libby Dam on white sturgeon recruitment and other resources in the system. The main objective for developing the model was to provide a tool that would aid in design of an experimental management program to define management measures that would benefit white sturgeon juvenile recruitment. The discussions and data synthesis required to develop the model, and the model simulations were used to eliminate unlikely hypotheses for sturgeon recruitment decline and to eliminate policies that provided unacceptable outcomes for other resources in the system. The model consists of three main components: 1) a hydrology submodel that uses historic inflows into Libby Reservoir and tributaries, and a reservoir operation simulation (for Libby, Duncan, and Corra

Linn dams) to allow users to develop realistic discharge scenarios; 2) an aquatic production submodel that simulates turbidity, nutrient dynamics, and macroinvertebrate production in the Kootenai River; and 3) a fisheries submodel that simulates the effects of various habitat impacts related to dam operations and other watershed changes (e.g. declining nutrient loading, flood plain development) on population dynamics of white sturgeon, kokanee, burbot, rainbow and redband trout, squawfish, and other species. The model simulations summarize the tradeoffs between power economics, flood protection, and fisheries benefits, as well as tradeoffs among species associated with different flow regimes.

F. <u>Strategy for Recovery</u>

Recovery of Kootenai River white sturgeon is contingent upon reestablishing natural recruitment, minimizing additional loss of genetic variability to the population, and successfully mitigating biological and physical habitat changes caused by human development within the Kootenai River basin and the construction and operation of Libby Dam. This recovery plan proposes conservation actions to benefit white sturgeon within the entire Kootenai River watershed in the United States and Canada. However, the Endangered Species Act does not impose any restrictions or commitments on Canada. This recovery plan describes a strategy for improving coordination and cooperation between the United States and Canada on the operation of Libby Dam with the operation of other hydroelectric facilities within the Kootenai River basin and elsewhere in the Canadian portion of the Columbia River basin. If required for recovery, a United States - Canada binational agreement could be entered into to aid Kootenai River white sturgeon recovery, as occurred for the endangered whooping crane.

Implementation or scheduling of tasks is also based on a priority system. <u>Priority 1</u> tasks are those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. <u>Priority 2</u> tasks are those actions that must be taken to prevent a significant decline in species population and habitat quality, or some other significant negative impact short of extinction. <u>Priority 3</u> tasks are all other actions necessary to provide for full recovery of the species. Proposed actions for native fishes have not been assigned a priority number. However, information from these actions will be useful to evaluate how resident fish are affected by conservation actions proposed for Kootenai River white sturgeon.

Actions (or tasks) that will have the highest priority for implementation include:

Restore natural recruitment to the Kootenai River white sturgeon population (Priority 1).

Recovery will require that suitable Kootenai River ecosystem functions, including augmented seasonal Kootenai River flows, are restored to ensure habitat conditions necessary for successful white sturgeon reproduction and recruitment, i.e. survival of juveniles during their first year of life and beyond. The first stated purpose of the Endangered Species Act is, " . . . to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." The continued preservation of the sturgeon solely through artificial propagation would not be considered recovery.

Use conservation aquaculture to prevent the extinction of Kootenai River white sturgeon (Priority 1).

One recovery objective for the Kootenai River white sturgeon population is to prevent extinction by developing and implementing, for at least the next 10 years, a conservation aquaculture program, i.e. hatchery propagation. A conservation aquaculture program will include protocols on broodstock collection, gene pool preservation, broodstock mating criteria, juvenile rearing, fish health, and stocking.

Monitor the survival and recovery of the Kootenai River white sturgeon and its ecosystem (Priority 1, 2, and 3).

Concurrent with efforts to restore natural recruitment and prevent the extinction of the Kootenai River white sturgeon, further research and monitoring are necessary on life history and habitat requirements of white sturgeon and other aquatic species within the Kootenai River ecosystem.

This information is essential to understand the population dynamics of other fish species and allow resource managers to evaluate the effectiveness of conservation measures in meeting recovery goals.

Update and revise recovery plan criteria and objectives (Priority 2).

The Recovery Plan for the White Sturgeon: Kootenai River Population will be updated and revised as additional information becomes available, recovery tasks are accomplished, and as environmental conditions change.

PART II - RECOVERY

A. Recovery Objectives

The short-term recovery objectives of this recovery plan (Plan) are to a) reestablish natural recruitment to the Kootenai River population of white sturgeon and b) prevent extinction through conservation aquaculture. Proposed recovery actions include providing additional Kootenai River flows to reestablish natural recruitment and using conservation aquaculture, i.e. hatchery propagation, to prevent extinction. Due to uncertainties in egg-through-yearling survival for wild white sturgeon and the general lack of recruitment since the mid-1960's, conservation aquaculture should be used to rear juvenile white sturgeon for release into the Kootenai River, and possibly Kootenay Lake, in each of the next 10 years. The Kootenai River white sturgeon population could be considered for downlisting to threatened status in approximately 10 years if downlisting criteria described in section B. Recovery Criteria below are achieved.

The long-term objectives are to provide suitable habitat conditions and restore an appropriate age structure and effective population size to ensure a self-sustaining Kootenai River population of white sturgeon.

Recovery actions proposed in this final Plan are intended to balance white sturgeon recovery with requirements for other fish species and recreational fisheries (Executive Order 12962 of June 7, 1995) within the Kootenai River drainage. In all but the most extreme low water years, the Plan should complement conservation measures designed by the National Marine Fisheries Service to meet Snake River chinook and sockeye salmon recovery objectives downstream in the Columbia River.

B. Recovery Criteria

Criteria for reclassification or downlisting to threatened status for Kootenai River white sturgeon include:

1. Natural production of white sturgeon occurs in at least 3 different years of a 10-year period. A naturally produced year class is demonstrated through detection by standard recapture methods of at least 20 juveniles from that class reaching more than 1 year of age, and;

2. The estimated white sturgeon population is stable or increasing and juveniles reared through a conservation aquaculture program are available to be added to the wild population each year for a 10-year period. For this purpose, a year class will be represented by the equivalent of 1,000 one-year old fish from each of 6 to 12 families, i.e. 3 to 6 female parents. Each of these year classes must be large enough to produce 24 to 120 white sturgeon surviving to sexual maturity. Over the next 10 years, the number of hatchery reared juvenile fish released annually will be adjusted depending upon the mortality rate of previously released fish and the level of natural production detected. Additionally, if measures to restore natural recruitment are successful, the conservation aquaculture program may be modified. Conversely, the Fish and Wildlife Service may recommend that the conservation aquaculture program be extended beyond 10 years if adequate natural recruitment to support full protection of the existing Kootenai River white sturgeon gene pool is not clearly demonstrated, and;

3. A long-term Kootenai River Flow Strategy is developed in consultation of interested State, Federal, and Canadian agencies and the Kootenai Tribe at the end of the 10-year period based on results of ongoing conservation actions, habitat research, and fish productivity studies. This strategy should describe the environmental conditions that resulted in natural production, i.e. recruitment (as described in criterion No. 1), with emphasis on those conditions necessary to repeatedly produce recruits in future years.

Recovery or delisting will be based on providing suitable habitat conditions and restoring an effective population size and age structure capable of establishing a self-sustaining Kootenai River population of white sturgeon. Specific delisting recovery criteria will be developed as new population status, life history, biological productivity, and flow augmentation monitoring information is collected. However, it will be approximately 25 years following approval of this recovery plan before delisting of the white sturgeon population can be considered. Twenty-five years is the approximate period for female white sturgeon added to the population during the next 10 years to reach maturity and reproduce to complete a new generation or spawning cycle.

Actions Needed to Initiate Recovery:

- Identify and restore white sturgeon habitats necessary to sustain white sturgeon reproduction (spawning and early age recruitment) and rearing while minimizing impacts on other uses of Kootenai River basin waters, e.g. recreational facilities and the resident fishery in Koocanusa Reservoir, Kootenay Lake, and Kootenai River.

- Develop and implement a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon. The conservation aquaculture program will include protocols on broodstock collection, gene pool preservation, propagation, juvenile rearing, fish health, and preservation stocking.

- Work within operational guidelines for Libby Dam based upon Kootenai Integrated Rule Curves (KIRC) to balance white sturgeon recovery with requirements for other fish species and recreational fisheries within the Kootenai River drainage, and VARQ to ensure that more water is available for white sturgeon, salmon, and all species in lower water years.

- Continue research and monitoring programs on life history, habitat requirements for all life stages, population status, and trends of the Kootenai River white sturgeon.

- Protect Kootenai River white sturgeon and their habitats using available regulatory mechanisms, including section 7 and 10 of the Endangered Species Act, section 404 of the Clean Water Act, and the Canadian Fisheries Act.

- Evaluate how changes in biological productivity in the Kootenai River basin affect white sturgeon and their habitats.

- Evaluate the effects of contaminants and possible additional biological threats, i.e. predation, on Kootenai River white sturgeon and their habitats.

- Increase public awareness of the need to protect and recover the Kootenai River white sturgeon.

- Balance white sturgeon recovery measures with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage.

- Secure funding for implementation of recovery tasks.

Recovery of the Kootenai River population of white sturgeon will require improved coordination between United States and Canadian governmental and nongovernmental organizations. In this Plan, the Fish and Wildlife Service acknowledges numerous programs underway through local, State, Tribal, Federal, and Canadian entities to address Kootenai River basin issues. Improved interagency coordination will ensure that these, and future programs, are compatible with recovery objectives proposed for the Kootenai River white sturgeon. Additionally, a United States - Canada binational agreement could be entered into to aid Kootenai River white sturgeon recovery efforts, as occurred for the endangered whooping crane.

The Fish and Wildlife Service will use the results of ongoing research and monitoring to update and revise the plan as needed.

C. Recovery Measures Narrative

Figure 11 outlines the proposed Kootenai River white sturgeon recovery measures. Recovery tasks 11, 21, 22, 23, 24, 25, 26, 32, 41, and 42, described as follows, are short-term recovery measures essential to prevent extinction of Kootenai River white sturgeon.

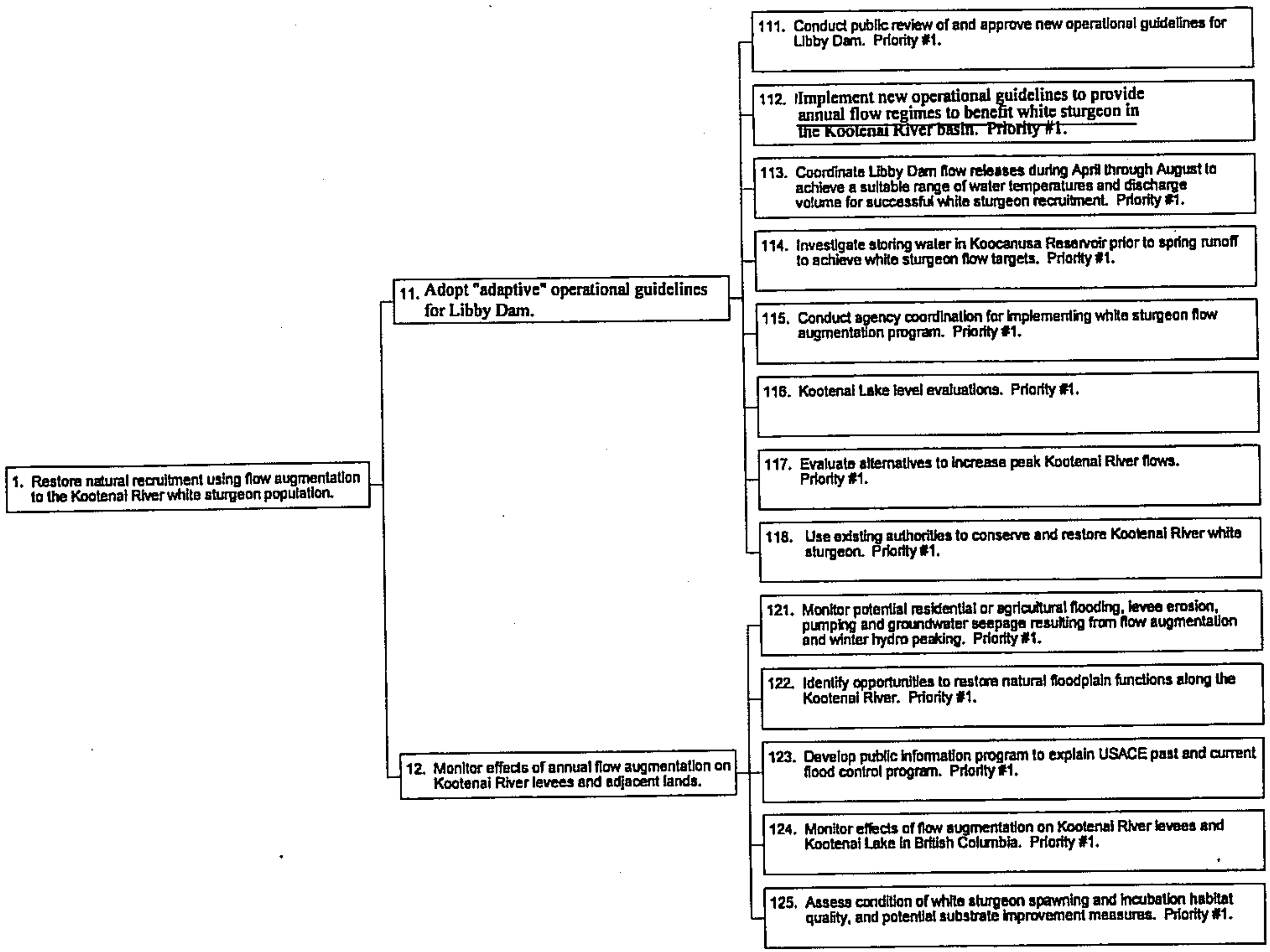

Figure 11. Flow chart summarizing Kootenai River white sturgeon recovery measures.

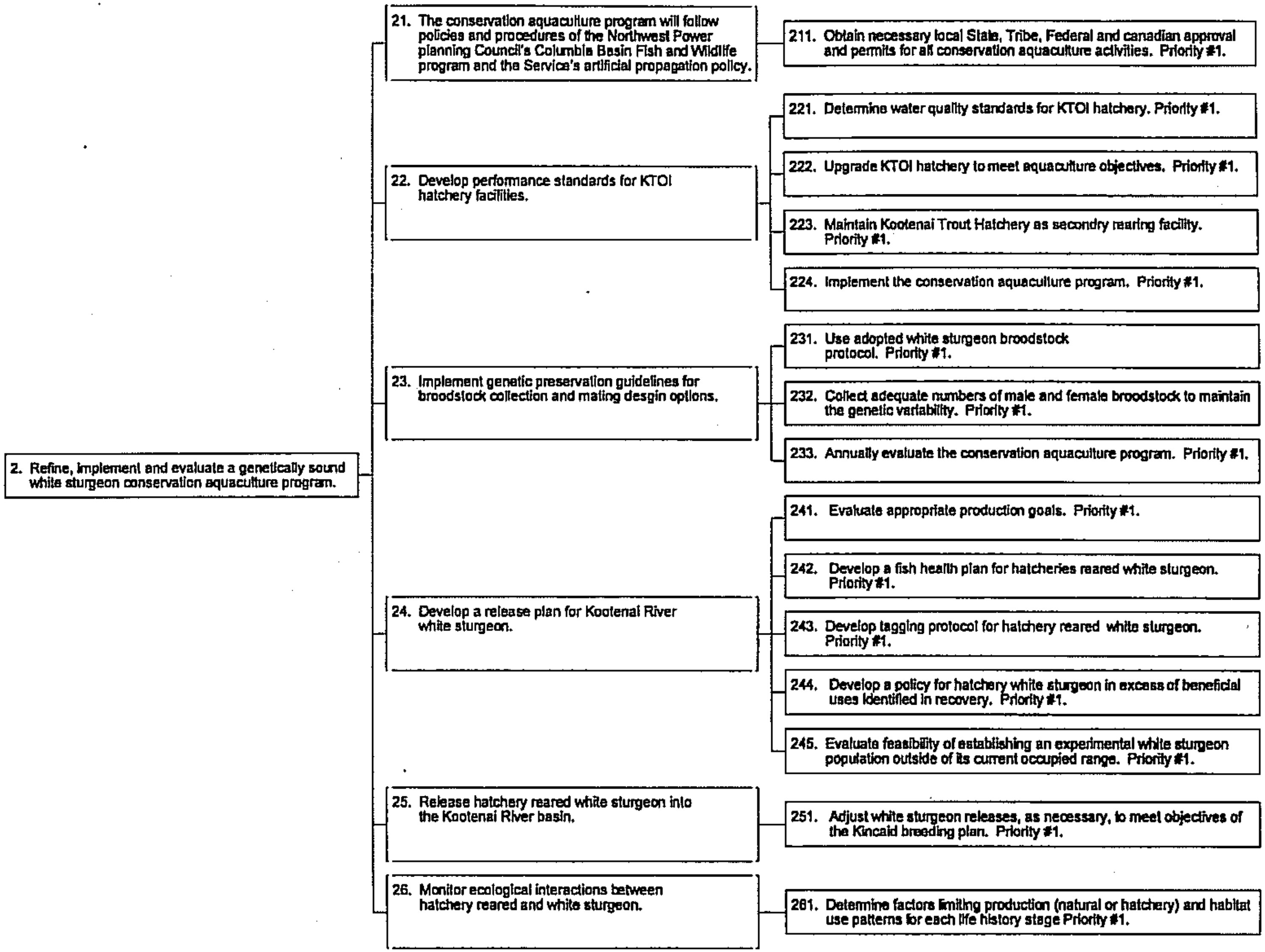

Figure 11. Continued

- 3. Conduct research on basic life history and monitor <u>the level of recruitment</u>, <u>survival</u> and <u>recovery of</u> Kootenai River white sturgeon.
  - 31. Describe basic life history information.
    - 311. Sample adult and juvenile white sturgeon in the Kootenai River and Kootenay lake. Priority #2.
    - 312. Collect and preserve tissue and blood samples for genetic analysis. Priority #2.
    - 313. Compile catch data to refine white sturgeon populations size estimates annually in the Kootenai River Basin. Priority #2.
    - 314. Develop a juvenile white sturgeon year class index. Priority #2.
  - 32. Describe Kootenai River flow requirements and Kootenay Lake elevations for naural spawning incubation, rearing, recruitment and survival of white sturgeon.
    - 321. Describe responses of spawning white sturgeon in various Kootenai River flows, water temperatures, DGS, and Kootenai Lake elevations. Priority #2.
    - 322. Annually measure white sturgeon spawning. Priority #2.
    - 323. Measure white sturgeon larval, fry, and juvenile abundance and distribution in the Kootenai River and Kootenay Lake annually. Priority #2.
    - 324. Quantify sturgeon spawning incubation habitat and early rearing habitat using FM. Priority #2.
  - 33. Conduct investigations on biological productivity in the Kootenai River.
    - 331. Assess the necessity of incresing nutrients in the Kootenai River. Priority #2.
    - 332. Use computer modeling to refine and analyze recovery tasks. Priority #2.
  - 34. Evaluate the effects of contaminants on white sturgeon.
    - 341. Compile existing information on contaminants in the Kootenai River. Priority #2.
    - 342. Conduct contaminant bioassess to evaluate the effects of selected chemicals on white sturgeon. Priority #2.

Figure 11. Continued

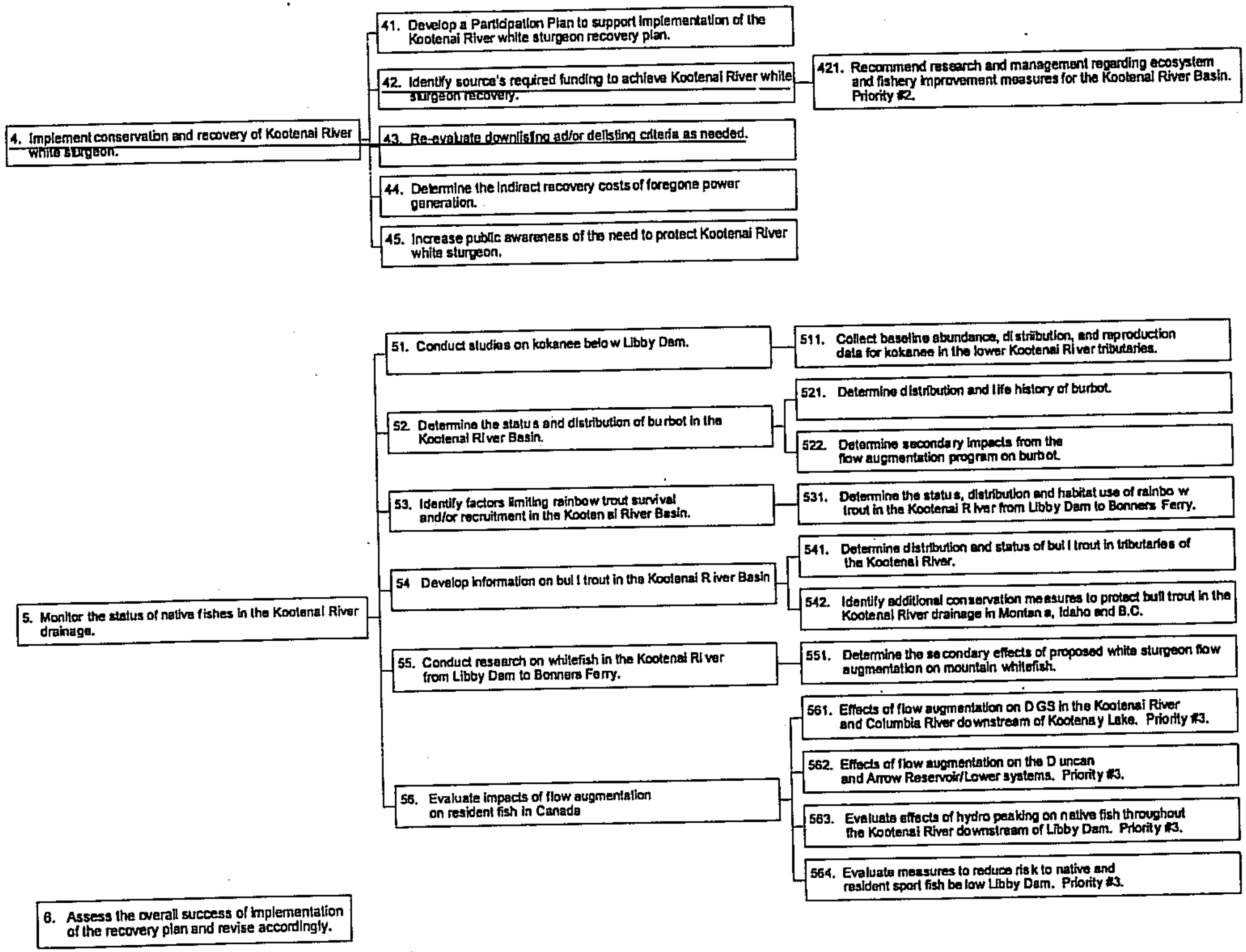

Figure 11. Continued

1 Restore Kootenai River white sturgeon natural recruitment using flow augmentation.

Recovery of the Kootenai River white sturgeon will require providing suitable habitat conditions so that the remaining wild white sturgeon can successfully reproduce and recruit as juveniles (greater than age 1) to the population. Restoring natural recruitment to ensure a self-sustaining white sturgeon population will require implementing new operational guidelines for Libby Dam such as using tiered flows (Kootenai Integrated Rule Curves) to set aside water volumes for spring sturgeon flows and VARQ (an enhanced flood control protocol) to ensure that more water is available for white sturgeon, salmon, and all species in lower water years. The VARQ is an alternative flood control protocol developed by the U.S. Army Corps of Engineers for regulating flood control at Libby Dam, while the Kootenai Integrated Rule Curves (KIRCs) are designed to balance white sturgeon recovery with requirements for other species and recreational fisheries within the Kootenai River basin. The effects of operations at Libby extend well beyond the Kootenai basin, and flow management decisions must consider resources throughout the Columbia River basin. Factors other than flow possibly affecting white sturgeon recruitment, i.e. contaminants, predation, biological productivity, are addressed in recovery tasks # 311 through 342.

11 Adopt "adaptive" operational guidelines for Libby Dam.

Specific flow requirements for natural white sturgeon spawning and successful recruitment in the Kootenai River remain largely unknown. Until flows that contribute to successful recruitment are established, annual Kootenai River flow augmentation for white sturgeon should be based on water availability in the upper Kootenai River basin. This Plan proposes working within Libby Dam operational guidelines based upon increasing reservoir refill probability by adopting an operations model such as (KIRCs) that balances white sturgeon flow targets with Koocanusa Reservoir water levels and other aquatic resources in the Kootenai River basin, and using flood control operations like VARQ to ensure additional water is available for white sturgeon, salmon, and all species in lower water years. Under these "adaptive" operational guidelines, flow targets will vary annually by water temperature, water volume, duration, and shape. The effects of flow and water temperature on various life stages of white sturgeon will also be monitored. This operational strategy was designed to balance resident fish concerns with power production, flood control, and Koocanusa Reservoir refill under varying water availability ranging from drought to flood conditions (Appendix C).

111 <u>Conduct public review and approve new operational guidelines for Libby Dam.</u>

Implementation of new reservoir operational guidelines will require improved coordination with Canadian water management entities such as the British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and hydro power producers such as BC Hydro. In addition, the adoption of new reservoir operational guidelines could be affected by the National Marine Fisheries Service's section 7 requirements relative to flows for listed Snake River salmon. In recognition of the need to meet the conservation requirements for sturgeon, salmon, and bull trout listed under the Endangered Species Act, the Fish and Wildlife Service and National Marine Fisheries Service will continue coordination on operations and flow augmentation programs with the goal of providing sufficient water for all listed species. Following final National Environmental Policy Act documentation and review, the North Pacific Division of the Army Corps of Engineers would issue a Record of Decision on adoption of new operational guidelines for Libby Dam.

112 <u>Implement new operational guidelines to provide annual flow regimes to benefit white sturgeon in the Kootenai River basin.</u>

Following completion of recovery task 111 and implementation by the Army Corps of Engineers of the new operational guidelines to manage Libby Dam operations, annual Kootenai River flow targets will be selected based on forecasted inflow volumes (i.e. reservoir inflow expected during April 1 through August 30 in million acre-feet). White sturgeon flow targets would represent minimum flows at Bonners Ferry (i.e. Libby Dam discharge plus unregulated runoff between Libby Dam and Bonners Ferry). There would be no specific Libby Dam flow augmentation for white sturgeon in an extended drought or low water years, e.g. critical water years (less than 4.8 million acre-feet), unless increased discharges are required for emergency flood control (see Appendix C for a more complete description).

Proposed water volume released for white sturgeon will be estimated using monthly volume runoff or inflow forecasts beginning in January. The final augmentation volume will be based on the May 1 forecast (Table 2). When the forecast underestimates the actual inflow volume, minimum white sturgeon flow targets may be exceeded as excess water is released to slow the rate of reservoir refill. Overestimation of seasonal runoff may impact Koocanusa Reservoir refill by releasing water to achieve the minimum white sturgeon flow target.

Actual water releases from Libby Dam by the Army Corps of Engineers and Bonneville Power Administration during April through August will be based upon section 7 consultation with the Fish and Wildlife Service (task 118) and fine tuned through in-season management based on known in-river conditions and recommendations by several coordinating entities as described in task 113.

Table 2. "Tiered" volumes of water for sturgeon flow enhancement to be provided at Bonners Ferry according to the April-August volume runoff forecast at Libby. Actual flow releases would be shaped according to seasonal requests from the Fish and Wildlife Service and in-season management of water actually available. Volumes are in addition to the Libby minimum release of 4,000 cfs. (maf = million acre feet)

Forecast runoff volume (maf) at Libby	Sturgeon flow volume (maf) at Bonners Ferry
$0.00 \leq$ forecast < 4.80	0.71
$4.80 \leq$ forecast < 6.00	1.42
$6.00 \leq$ forecast < 6.70	1.77
$6.70 \leq$ forecast < 8.10	2.56
$8.10 \leq$ forecast < 8.90	3.89
$8.90 \leq$ forecast	4.77

113 Coordinate Libby Dam flow releases during April through August to achieve a suitable range of water temperature and discharge volume for successful white sturgeon recruitment.

The adoption of new reservoir operational guidelines will provide flexibility to assure that the flow augmentation for successful white sturgeon recruitment corresponds with suitable water temperatures. At Libby Dam, operators are able to release or selectively withdraw reservoir water from appropriate depths to achieve a more natural temperature regime as measured at Bonners Ferry. As appropriate water temperatures (10 to 14 degrees Celsius [50 to 57 degrees Fahrenheit]) become available at the appropriate outlet depth, and in consideration of ambient weather conditions and tributary additions downstream, Libby Dam discharge can be regulated to achieve the optimal mix of Kootenai River flow and temperature.

Annual flow management plans to manage water releases from Libby Dam during April through August will be based on coordination between the Army Corps of Engineers, Bonneville Power Administration, National Marine Fisheries Service, Fish and Wildlife Service, and other coordinating entities (e.g., State of Montana; Kootenai - Salish Nation; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries; and BC Hydro), and implemented through the Regional Forum's Technical Management Team or its successor. These entities will use a systematic approach to evaluate (task 321) how flow shaping, timing, water volume, water depth, water temperatures, prespawning flows, and substrate type may affect white sturgeon spawning behavior and recruitment. For example, the flow management plan would consider water availability in a given year and attempt to shape flows to mimic Kootenai River flows and water temperatures observed in years when some white sturgeon recruitment occurred, e.g. 1970, 1974, 1980, and 1991. White sturgeon should respond to these stimuli by forming prespawning aggregate groups below Bonners Ferry in anticipation of moving upstream to spawn where suitable incubation, water temperature, water depths, water velocities, and substrate type exist. Evaluating the success of an annual flow management plan will be part of task 321; with success partially defined as detecting white sturgeon eggs spawned into suitable habitats and documenting some level of natural recruitment.

At present, the Army Corps of Engineers and Montana Department of Fish, Wildlife, and Parks have an agreement to release water no closer than 16 meters (50 feet) beneath the Koocanusa Reservoir surface elevation to reduce the loss of fish (primarily kokanee) through the turbines (entrainment). Recent sampling of fish entrainment (Skaar et al. 1996) revealed that downstream losses of various fish species are severe in June, particularly when reservoir levels are low. However, to achieve temperature criteria for white sturgeon spawning in the Bonners Ferry reach, it has been necessary to withdraw surface water (upper 10 to 11 meters [30 to 35 feet]) from Koocanusa Reservoir during May and June. Methods of reducing entrainment should be pursued as part of the annual coordination to balance the effects of thermal control and flow augmentation on the reservoir fishery.

114 Investigate storing water in Koocanusa Reservoir prior to spring runoff to achieve white sturgeon flow targets.

The Montana Department of Fish, Wildlife, and Parks has shown that storing water behind Libby Dam during the winter period not only increases water availability for white sturgeon flow augmentation but also reduces impacts to the Koocanusa Reservoir fishery. By storing water for white sturgeon, reservoir elevations should remain more favorable for biological production and refill probability will be enhanced. Water releases for sturgeon then continue downstream to aid juvenile anadromous fish migration to the Pacific Ocean. Bull trout, west-slope cutthroat trout, rainbow trout, and possibly burbot, in the Kootenai River may respond favorably to this operating strategy because the timing of releases corresponds with their life cycle requirements.

The VARQ was a flood control strategy developed by the U.S. Army Corps of Engineers while the KIRCs incorporate a flood control strategy that is compatible with flood control rule curves for Libby Dam under evaluation by the Army Corps of Engineers. The rule curves of both of these operational guidelines facilitate storing additional water prior to the spring runoff. The Army Corps of Engineers, in coordination with appropriate United States and Canada fishery agencies, should complete their analysis as it may allow for the storage of additional water available for white sturgeon flow augmentation and the minimization of impacts to Koocanusa Reservoir through more frequent refill.

115 Conduct agency coordination for implementing white sturgeon flow augmentation program.

The Army Corps of Engineers, Bonneville Power Administration, Fish and Wildlife Service, National Marine Fisheries Service, First Nations, BC Hydro, appropriate States, and Canada will require specific information to plan and implement annual Kootenai River white sturgeon recruitment flow proposals. These entities should coordinate annually to ensure that regional flood control requirements will be met, adequate water volume is stored in Koocanusa Reservoir, and system power needs and regional aquatic resource issues are addressed in years when white sturgeon flow augmentation will occur.

Prior to implementing the operational changes in the way water is stored and released from Libby Dam, the operating agencies should also cooperate using Columbia River Treaty protocols. Protocol V of the Treaty describes responsibilities of the entities and requires cooperation on a continuous basis to coordinate the operation of

Libby Dam with the operation of hydroelectric plants on the Kootenai River and elsewhere in Canada in accordance with the provisions of Articles XII (5), XII (6), IV (2a), and IV (2k) of the Treaty.

116 <u>Kootenay Lake level evaluations.</u>

One potential reason Kootenay River white sturgeon spawn in areas of apparent suboptimal conditions may be the result of implementing the 1938 International Joint Commission (IJC) Order, controlling the level of Kootenay Lake. The International Joint Commission, formed to ensure property rights are not impacted by actions of the neighboring countries, responded to a proposal to construct a hydroelectric facility at the outlet of Kootenay Lake by issuing an order that effectively controlled the surface elevation of Kootenay Lake. However, with the regulation of inflows by Libby Dam, the interpretation of the International Joint Commission order has resulted in Kootenay Lake mean maximum levels being approximately 2 meters (6.6 feet) lower since the construction of Libby dam in 1972. The Fish and Wildlife Service believes the lower maximum lake elevation may contribute to the lack of successful white sturgeon reproduction by altering river stage, flow velocity, and substrate relationships in the vicinity of sturgeon spawning habitat near Bonners Ferry. Velocities are important to spawning behavior and locations. Altered river velocities resulting from these lake elevation changes could partially explain the recent observation of white sturgeon spawning in the Kootenai River farther downstream than expected and over a sand substrate where eggs may not survive. Further discussion between appropriate Canada and United States officials should occur to determine whether lake elevation should be determined based on regulated or natural inflows. Other issues of concern as part of this evaluation include effects of International Joint Commission actions on Koocanusa Reservoir refill, and seasonal flooding effects along the Kootenai River and Kootenay Lake.

117 Evaluate alternatives to increase peak Kootenai River flows.

Examine alternatives to reliably provide peak flows in the Kootenai River at Bonners Ferry, Idaho, in the 1,100 to 1,400 cubic meters per second (40,000 to 50,000 cubic feet per second) range during the sturgeon spawning period. With the existing Libby Dam configuration two alternatives exist. The Water Resources Development Act of 1996 authorized appropriation of $16 million to complete the installation of existing generating units 6 through 8 in Libby Dam. Since these generating units are also connected to the selective withdrawal system they could increase peak flows of temperature regulated waters by as much as 60 percent. However, flood control and public safety considerations are important to that discussion. Use of the spillway, if it were modified with fliplips to reduce dissolved gas in outflows, might be an alternative to additional generating units. However, in years of high runoff, the spillway might not be available because the reservoir surface would probably be below the spillway crest elevation of 2,450 feet, for flood control purposes. Furthermore, in such situations, reservoir temperature stratification is still essentially nonexistent in early June, making warmer water difficult to obtain. This may also provide benefits to resident fish including bull trout in the Kootenai River downstream of Libby Dam if less conservative flood rule curves are adopted (Kootenai Integrated Rule Curves) and spill frequency increases.

118 Use existing authorities to conserve and restore Kootenai River white sturgeon.

Section 7(a) of the Endangered Species Act requires Federal agencies to use their authorities to carry out programs to conserve endangered and threatened species. The Fish and Wildlife Service will continue to request that the Army Corps of Engineers annually evaluate the direct and indirect effects of Libby Dam operations on the Kootenai River white sturgeon under section 7(a).

12 Monitor effects of annual flow augmentation on Kootenai River levees and adjacent lands.

The monitoring program begun in 1995 to evaluate the physical impacts of flow augmentation on Kootenai River levees and adjacent lands downstream of Bonners Ferry should be continued by the Army Corps of Engineers and the British Columbia Ministry of Environment, Land, and Parks. The Army Corps of Engineers should identify areas where levee repairs may be necessary to protect developed areas and also identify areas where levees can be removed or left in their current state. The biological evaluation of potential impacts and benefits to resident fish and other aquatic resources will be conducted through implementing recovery tasks 32 through 562.

121 Monitor potential residential or agricultural flooding, levee erosion, pumping, and groundwater seepage resulting from flow augmentation and winter hydro peaking.

The Army Corps of Engineers' annual monitoring report for the 1995 flow augmentation program should include a description of seepage-caused inundation of agricultural lands flooded, levee erosion from peak spring flows and winter hydro peaking, and any flooding that may have resulted from white sturgeon augmentation flows. The results of this study will be useful in developing procedures and guidelines for implementing an annual levee monitoring program.

122 Identify opportunities to restore natural flood plain functions along the Kootenai River.

Based on the results of task 121, the action agencies should identify opportunities to restore natural flood plain and wetland functions along the Kootenai River downstream of Bonners Ferry in Idaho. For example, identify landowners in flood-prone areas that may be willing to sell, lease, or assign conservation easements on portions of their land suitable for restoring natural flood plain functions. Funding may be available to implement this task through Section 206 Aquatic Ecosystem Restoration of the Water Resources Development Act of 1996.

The British Columbia Ministry of Environment, Lands, and Parks should work with the Creston Valley Wildlife Management Authority to further investigate altered Kootenai River flooding patterns to improve white sturgeon habitat.

123 Develop a public information program to explain Army Corps of Engineers past and current flood control program.

The Army Corps of Engineers should develop and distribute information on flood control operations and potential risks as part of their annual public meetings, as well as in any National Environmental Policy Act documentation of Kootenai River flow augmentation proposals.

124 Monitor effects of flow augmentation on Kootenay River levees and Kootenay Lake in British Columbia.

Proposed flow augmentation measures are designed to benefit white sturgeon reproduction primarily in the United States portion of the Kootenai River. However, physical impacts may also occur in Canada along the Kootenay River and Kootenay Lake. The British Columbia Ministry of Environment, Lands, and Parks should develop and implement a monitoring program in Canada similar to recovery task 121.

125 Assess the condition of white sturgeon spawning and incubation habitat quality, and potential substrate improvement measures.

Researchers generally agree that white sturgeon egg deposition and spawning downstream from Bonners Ferry in low velocity, silt/sand deposition areas of the Kootenai River are not currently occurring in optimal habitat for successful egg incubation, hatching, and larval rearing. An evaluation on the future use of artificial spawning and rearing substrates should be conducted. Artificial substrates have been introduced for various sturgeon species in North America, Russia, and France with varying degrees of success. These habitat projects have involved placing rock and boulder substrates in known spawning reaches of the target species.

2 Refine, implement, and evaluate a genetically sound conservation aquaculture program.

To prevent extinction of the Kootenai River white sturgeon population, a conservation aquaculture program will be implemented and evaluated for a minimum of 10 years (1999 through 2008). This program will help preserve the 10 population's remaining wild genetic variability and will begin to rebuild the natural age class structure of the wild white sturgeon population over the next 10 years. If measures to restore natural white sturgeon recruitment (described in tasks 111 to 116) are successful, the conservation aquaculture program may be adjusted before 2009. Components of this conservation aquaculture program include the following tasks:

21 The conservation aquaculture program will follow the policies and procedures of the Northwest Power Planning Council's Columbia Basin Fish and Wildlife Program and the Fish and Wildlife Service's artificial propagation policy.

All white sturgeon produced and released in the Kootenai River will be consistent with management goals and policies. Fishery managers from the participating agencies will review existing policies and goals for consistency with the conservation aquaculture program. Additionally, they will ensure that the conservation aquaculture program is consistent with the Northwest Power Planning Council Fish and Wildlife Program and the Fish and Wildlife Service's artificial propagation policy.

211 Maintain necessary local, State, Tribal, Federal, and Canadian approval and permits for all conservation aquaculture activities.

Appropriate agencies will be properly informed of conservation aquaculture activities. Required permits for broodstock collection, transport, and release of white sturgeon in the Kootenai River system will be renewed through consultation with the Fish and Wildlife Service and appropriate State agencies. For example, a section 10 (a)(1)(A) permit authorized under the Endangered Species Act is required in order to collect, propagate, rear, and release white sturgeon.

22 Develop performance standards for the Kootenai Tribe of Idaho hatchery facilities.

Hatchery performance standards for white sturgeon are necessary to successfully spawn and rear healthy Kootenai River white sturgeon. For best results, the existing Kootenai Tribe of Idaho white sturgeon hatchery should be operated following well defined performance standards. The Kootenai Tribe of Idaho, in coordination with the Idaho Department of Fish and Game; Bonneville Power Administration; British Columbia Ministry of Environment, Lands, and Parks; Montana Department of Fish, Wildlife, and Parks; and the Fish and Wildlife Service, will develop a set of performance standards that include a description of suitable facilities, water quality standards, rearing capacities, and egg hatching/rearing protocols.

221 Maintain water quality standards for Kootenai Tribe of Idaho hatchery.

A reliable water supply with acceptable water quality is needed to ensure that healthy white sturgeon are reared in the Kootenai Tribe of Idaho hatchery. Water quality standards will be determined since the main hatchery water source is the Kootenai River. The physical characteristics of the water in the Kootenai River are variable throughout the year. Water quality factors monitored weekly by the Kootenai Tribe of Idaho include water temperature, dissolved gases, turbidity, alkalinity and hardness, nitrite, contaminants, and pathogens.

222 Upgrade Kootenai Tribe of Idaho hatchery to meet conservation aquaculture objectives.

To achieve the proposed conservation aquaculture objectives, the current Kootenai Tribe of Idaho hatchery near Bonners Ferry will require additional facility improvements and expansion. Some of the hatchery needs include additional rearing capabilities, a water sterilization system, a sediment removal system, and a supplemental oxygen system. Upgrades to the existing facility, begun in 1998, will enable the Kootenai Tribe of Idaho to remove sediment and bacteria from river water, improve water capacity, and moderately control water temperature.

223 Maintain Kootenay Trout Hatchery as secondary rearing facility.

At present, there is the risk of losing hatchery reared juvenile white sturgeon due to accidents or other unanticipated events, e.g. power outage or loss of water supply. To minimize the risk of losing one or more white sturgeon families held in the Kootenai Tribe of Idaho hatchery until fish are large enough to be marked and released, the Kootenai Tribe of Idaho will work with appropriate

Canadian officials to establish the Kootenay Trout Hatchery in Fort Steele, British Columbia as a secondary rearing or "fail-safe" facility within the Kootenai River basin.

224 <u>Implement the conservation aquaculture program.</u>

The Bonneville Power Administration has funded the design, development, construction, and operation of the Kootenai Tribe of Idaho hatchery since 1988 as directed by measure 10.4B.1 in the Northwest Power Planning Council Program. The hatchery successfully spawned, incubated, and reared white sturgeon in 1991, 1992, 1993, and 1995. This program is vital to the recovery of the white sturgeon population and the Bonneville Power Administration should continue to fund the Kootenai Tribe of Idaho hatchery from 1999 to 2008. The Kootenai Tribe of Idaho and Idaho Department of Fish and Game will implement the conservation aquaculture program to prevent the extinction of the Kootenai River population of white sturgeon.

23 <u>Implement genetic preservation guidelines for broodstock collection and mating design options.</u>

In 1993, the Bonneville Power Administration funded the development of a breeding plan for the Kootenai River white sturgeon (Kincaid 1993). The breeding plan provided a systematic approach to preserve the white sturgeon population's genetic variability while management agencies continued work to restore Kootenai River habitat conditions necessary to reestablish natural recruitment (Appendix D).

231 <u>Use adopted white sturgeon broodstock collection protocol.</u>

Broodstock collected will represent the genetic variability of the population by taking representative samples with respect to run timing, size, sex, age, and other important traits to maintain long-term fitness. A broodstock collection protocol developed by the

Kootenai Tribe of Idaho and the Idaho Department of Fish and Game is summarized in Appendix E. The protocol, partially adapted from Kincaid's (1993) breeding plan, is designed to maximize collection efficiency, reproductive success, and genetic variation of broodstock while minimizing negative effects of handling stress on the natural spawning white sturgeon in the Kootenai River.

232 Collect adequate numbers of male and female broodstock to maintain the genetic variability.

Annually collect and spawn three to six females and six to nine males for broodstock (Appendix E). These fish will be held in the Kootenai Tribe of Idaho hatchery for 1 to 2 months until they are ready to be spawned. This protocol is adapted from Kincaid's (1993) breeding plan and will allow the genetic variability of the wild population to be maintained over the next 10 years.

The breeding plan incorporates a spawning matrix to minimize white sturgeon inbreeding and genetic drift. This spawning matrix is designed to maximize the diversity of genetic material passed on from artificially spawned adult white sturgeon when the hatchery-reared fish are released back into the wild population. Maximizing genetic diversity is important for the long term fitness and survival of Kootenai River white sturgeon. See Appendix D (Kincaid 1993) for more information.

233 Annually evaluate the conservation aquaculture program.

The conservation aquaculture program should be evaluated annually to ensure that the genetic variability of the Kootenai River white sturgeon population is preserved. Tissue samples from all broodstock and representative numbers of progeny are currently being archived for future electrophoretic or DNA analysis to determine the genetic baseline for the white sturgeon population. The genetic baseline is necessary to determine if the broodstock collection protocol and spawning matrix are avoiding inbreeding and genetic drift.

24 Develop a release plan for Kootenai River white sturgeon.

A plan will be developed to govern the release of hatchery-reared fish so that conservation aquaculture objectives are met. Fish size, release time, and release locations are three factors that may affect survival of hatchery-reared sturgeon in the Kootenai River. The size of hatchery-reared sturgeon released into the Kootenai River should take into account predation and food availability to achieve maximum growth. The release plan will specify release sizes, release times, and release locations for hatchery-reared white sturgeon.

241 Evaluate appropriate production goals.

Annual production goals will range from 6,000 to 12,000 yearling white sturgeon depending on how many families are produced in any given year. This goal is designed to produce the 24 to 120 sexually mature sturgeon in each year class needed to rebuild a more natural age structure of Kootenai River white sturgeon. Based on 7 years of survey information, female and male Kootenai River white sturgeon reach sexual maturity as young as age 22 and 16 years, respectively (Vaughn L. Paragamian, IDFG, pers. comm.). White sturgeon releases should begin as soon as juvenile white sturgeon from the 1998 year class are large enough for marking, and continue for a minimum of 10 years. The production goal was developed using estimates of longevity, current survival estimates, and average age to maturity. Production goals may be altered based on the approval and future operation of a secondary backup rearing facility (see task 223).

242 <u>Develop a fish health plan for hatchery-reared white sturgeon.</u>

Fish health protocols will be developed to ensure that hatchery-reared white sturgeon available for release into the Kootenai River are generally healthy and disease free. Protocols will include a health inspection program for all white sturgeon life stages and prophylactic measures to prevent disease transfer in the hatchery. It is recommended that the health inspection program be administered by certified fish pathologists. These protocols will help minimize adverse impacts on the wild population and increase survival of hatchery-reared white sturgeon released into the Kootenai River basin.

243 <u>Develop tagging protocols for hatchery-reared white sturgeon.</u>

Permanent marking and tagging techniques are necessary to differentiate hatchery-produced white sturgeon from naturally produced white sturgeon in the Kootenai River. Protocols should use a combination of tagging methods (e.g. Passive Integrated Transponder Tags, scute removal patterns, and oxytetracycline). All fish must be permanently tagged to allow future identification by family and year class. Standardized tagging and collection methods will be developed to ensure that all appropriate information is recorded. The tagging protocol will be coordinated and approved by the Kootenai Tribe of Idaho; Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the U.S. Fish and Wildlife Service.

244 **Develop a policy for hatchery-reared white sturgeon produced in excess of beneficial uses identified in the recovery plan.**

The Kootenai Tribe of Idaho; Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the U.S. Fish and Wildlife Service will decide on the disposition of surplus juvenile white sturgeon. Once production goals have been met, beneficial use of surplus white sturgeon may include 1) establishment of a live gene bank or refugia population (task 245); 2) genetic analysis (mitochondrial DNA, nuclear DNA, or electrophoresis); 3) contaminant bioassays; 4) viral and bacterial research; 5) permanent marking techniques; 6) public displays and other educational purposes. Any fish remaining after all beneficial uses have been identified and addressed will be euthanized.

245 **Evaluate feasibility of establishing an experimental white sturgeon population outside of the current occupied range.**

When preserving any species, the probability of its persistence increases dramatically if that species exists in several populations. A nonessential experimental population of white sturgeon established somewhere in the Kootenai River basin would provide a long-term source of gene pool preservation, i.e. hatchery-reared fish, which would be available to augment the existing population if mortality rates are greater than expected or some natural catastrophe occurs. The Fish and Wildlife Service, in coordination with the affected State and Canadian entities, should evaluate the feasibility of establishing such a population, identify possible locations, e.g. Koocanusa Reservoir or Duncun Reservoir, and identify appropriate permits and disclosure documentation.

25 Release hatchery-reared white sturgeon into the Kootenai River basin.

Following completion of tasks 241 through 244, up to 1,000 juvenile white sturgeon per family will be released annually into the Kootenai River beginning in 1996. Based on the breeding plan developed by Kincaid (Appendix D and E), family releases will include the same number of juvenile sturgeon per year class to maintain the genetic variability of the Kootenai River white sturgeon population. Release times and locations will be developed to ensure optimal survival of hatchery-reared white sturgeon. Prior to release, white sturgeon will be tested for disease and visually inspected for physical deformities. Fish with obvious physical deformities will not be released and will be euthanized.

251 Adjust white sturgeon releases, as necessary, to meet objectives of the Kincaid breeding plan.

Based on implementing task 241 and using the monitoring results of recovery task 26, it may be necessary to adjust the numbers of hatchery-reared fish released in order to meet the goal of producing 4 to 10 spawning adult white sturgeon per family. Actual release numbers will be dependent upon the level of natural white sturgeon survival and recruitment detected for a given year. (Appendix D)

26 Monitor ecological interactions between hatchery-reared and wild sturgeon.

Interactions between hatchery-reared and wild white sturgeon will be monitored. A monitoring plan will be developed to ensure that hatchery white sturgeon are meeting the goals of the conservation aquaculture program. For example, survival and growth rates of released sturgeon are currently uncertain. Therefore, it is necessary to monitor released fish to determine survival and growth rates in the Kootenai River and Kootenay Lake in order to evaluate whether the Kincaid goal of producing 4 to 10 spawning adults per family spawned is being met.

261 Determine factors limiting production (natural and hatchery) and habitat use patterns for each life history stage.

A total of 2,588 hatchery-reared juvenile white sturgeon from 1991, 1992, 1993, and 1995 year classes have been released into the Kootenai River. Some of these fish will be captured at regular intervals to determine habitat preferences, movement, distribution, growth rate, food preferences, survival, and interactions with wild white sturgeon. This information will be used to determine habitat availability for juvenile white sturgeon, and identify additional areas to sample for wild white sturgeon spawning in the Kootenai River system.

3. Conduct research on basic life history and monitor the level of recruitment, survival, and recovery of Kootenai River white sturgeon.

Recovery of the Kootenai River white sturgeon can be achieved only by restoring the ecosystem upon which the fish depends. In addition to the interruption of natural spring runoff, other physical, chemical, and biological factors are believed to negatively affect the reproduction and survival of Kootenai River white sturgeon. These factors include habitat changes due to impounding water, diking, backwater habitat loss, changing levels of Kootenay Lake and the Kootenai River, altered bed-load transport rates, siltation, reduced productivity, nutrient loss, and water temperature modification. Potential biological factors include a declining effective population size, egg suffocation, lack of interstitial space, larval starvation, and predation on early life stages of white sturgeon. A better understanding of the white sturgeon life history and physical and biological factors affecting survival is necessary for developing specific recovery criteria and evaluating the success of proposed recovery measures.

31 Describe basic life history information.

Although much has been learned regarding the life history of Kootenai

River white sturgeon, further information regarding growth, longevity, age of maturation, migration patterns, specific spawning locations, egg, larvae and juvenile survival, and food selection is needed. This information will help document the ecological needs of the Kootenai River white sturgeon and also help to determine population viability.

311 <u>Sample adult and juvenile white sturgeon in the Kootenai River and Kootenay Lake.</u>

Collect biological information from captured fish including length, weight, girth, sex, pectoral fin samples for aging, and reproductive stage. This information will be useful to determine accurate age and growth rates of white sturgeon and determine environmental conditions necessary for natural reproduction and recruitment. As many as 120 sonic or radio transmitters previously attached to white sturgeon for monitoring purposes are still active or attached to free roaming fish. Most of these transmitters were attached with stainless steel wire that persists beyond the expected battery life. The Idaho Department of Fish and Game; Bonneville Power Administration; Montana Department of Fish, Wildlife, and Parks; and Kootenai Tribe of Idaho will evaluate the need to continue attaching transmitters to additional white sturgeon each year to fulfill research and monitoring needs. Only nonpermanent attachment methods should be used where feasible to ensure that transmitters remain attached only as long as necessary.

312 <u>Collect and preserve tissue and blood samples for genetic analysis.</u>

Tissue samples are being archived for future electrophoretic or DNA fingerprinting analysis to determine the genetic baseline for the population. This effort should be expanded basin wide to include tissue samples from white sturgeon collected in the West Arm, North Arm, and South Arms of Kootenay Lake; and Duncun Reservoir.

313 Compile catch data to annually refine white sturgeon population size estimates in the Kootenai River basin.

Information regarding the number of juveniles and adults in the Kootenai River system is necessary to develop and prioritize short and long term recovery objectives. Catch data should be compiled and analyzed annually to determine what the natural age class structure of the population is and the effective population size are relative to recovery criteria.

314 Develop a juvenile white sturgeon year class index.

The results from annual juvenile white sturgeon sampling studies will be useful to management agencies to develop an index of annual year class strength. This method will also be useful to document the effect of flow augmentation on white sturgeon natural recruitment in meeting recovery criteria, and also detect significant differences in year-class abundance.

32 Describe Kootenai River flow requirements and Kootenay Lake elevations for natural spawning, incubation, rearing, recruitment, and survival of white sturgeon.

Specific flow requirements for natural white sturgeon spawning that result in successful recruitment are not yet well defined. However, the best available information on the relationship between Kootenai River flows and recruitment comes from collecting naturally reared recruited year classes of 1970, 1974, 1980, and possibly 1991. In these years, peak flow events at Porthill coincident with water temperature of 11 to 13 degrees Celsius (51 to 55 Fahrenheit) ranged from 708 cubic meters per second (25,000 cubic feet per second) in 1980 to 1,841 cubic meters per second

(65,000 cubic feet per second) in 1970. However, the strongest recent year class, 1974 had flow peaks of 1,416 and 1,558 cubic meters per second (50,000 and 55,000 cubic feet per second) at Porthill.

With the regulation of inflows by Libby Dam the interpretation of the Integrated Rule Curves order has resulted in Kootenay Lake mean maximum levels being more than 2 meters (6.6 feet) lower since the construction and operation of Libby Dam in 1974. We believe that lower maximum lake elevation may have contributed to the lack of successful white sturgeon reproduction in the Kootenai River by altering river stage, flow velocity, and substrate relationships in the vicinity of sturgeon spawning habitat near Bonners Ferry. Essentially, with lower Kootenay Lake levels the backwater effect of the lake is not as pronounced and therefore the white sturgeon detects suitable velocities farther downstream in the area of the sand substrates. As evidence, in 1994, 1995, and 1996, as Kootenai River peak flow and lake stage increased progressively, white sturgeon egg collections occurred increasingly farther upstream near Bonners Ferry (Paragamian et al. 1996).

Another important component of this recovery plan is to evaluate whether implementing recovery tasks 112 and 113 results in successful white sturgeon recruitment. This would entail using a systematic approach to evaluate how flow shaping, timing, water volume, water temperatures, and substrate type affect white sturgeon spawning behavior and recruitment. Also, with young-of-the-year fish produced in the system, we may begin to evaluate other factors affecting early age survival in the Kootenai River ecosystem.

321 <u>Describe the response of spawning white sturgeon to various Kootenai River flows, water temperatures, gas supersaturation, and Kootenay Lake elevation.</u>

Potential spawning white sturgeon will be captured and tagged with ultrasonic and radio transmitters. Both females and males will be tracked daily using telemetry gear prior to and throughout the spawning season. Habitat used by tagged adults will be described including depth, substrate, water temperature, and mean column velocities.

Habitat use curves will be developed for white sturgeon spawning in the Kootenai River. Detailed maps of the movement and distribution of tagged sturgeon from April through September will also be developed. This information will be used to evaluate the success of proposed flow augmentation measures as described in task 11 in providing natural recruitment, and also useful in establishing habitat based recovery criteria as part of task 43.

Gas supersaturation (DGS) in the Kootenai River originating from Libby Dam may influence white sturgeon survival and riverine health. Although adult white sturgeon occupy deeper water and are less prone to gas bubble trauma, larvae and juveniles using shallow river margins and backwater sloughs may be influenced directly or indirectly (via impacts on the food supply) by elevated gas levels. Measurements of gas concentrations by the Montana Department of Fish, Wildlife, and Parks during Libby Dam spills in the 1970's revealed that saturation levels violated current Montana State water quality standards (greater than 110 percent total dissolved gas) in the Kootenai River. Supersaturated water persisted downstream beyond Kootenai Falls into the river reach inhabited by white sturgeon and their prey. This monitoring program should measure dissolved gas levels in the Kootenai River downstream of Libby Dam to assure that white sturgeon recovery is not compromised by elevated gas concentrations. Recent studies on white sturgeon larvae in the lower Columbia River revealed changes in swimming ability and increased vulnerability to predation due to gas supersaturation at sublethal exposure (Counihan et al. 1998).

This analysis will also relate the level of white sturgeon spawning and recruitment to Kootenay Lake levels. Since Libby Dam flow regulation began, Kootenay Lake maximum spring elevations have decreased compared to pre-Libby Dam conditions. Decreased lake elevations would reduce the backwater effect of Kootenay Lake and thereby alter velocity patterns upstream in the Kootenai River. Velocities are important to spawning behavior and locations. Altered river velocities resulting from these lake elevation changes could partially explain the recent observation of white sturgeon spawning in the Kootenai River farther downstream than expected and over a sand substrate where eggs may not survive.

322 Annually measure white sturgeon spawning.

Artificial substrate mats, D-ring plankton nets, and predator fish stomachs will be used to sample eggs in the Kootenai River. Physical habitat parameters at egg collection sites will be measured including water depth, river bottom type, and mean water column velocity. Predator fish stomachs should be removed and examined for the presence of white sturgeon eggs.

Spawning can be verified by collection of eggs during the flow augmentation period. A relative index of the number of spawning episodes that occurred will be developed. Fertilized white sturgeon eggs will be analyzed to determine developmental stage. Combined with water temperature during the incubation period, this information will be used to back-calculate time of spawning and associated physical habitat parameters.

323 Measure white sturgeon larvae, fry, and juvenile abundance and distribution in the Kootenai River and Kootenay Lake annually.

Year class abundance can be determined for most types of fish during the first year of life. As yet there are no reliable techniques for determining year-class abundance of young-of-the-year or age 1 white sturgeon in the Kootenai River basin. The monitoring program (described under task 3) will continue to use and evaluate a variety of traps, trawls, and nets to reliably sample white sturgeon larvae and fry in the Kootenai River system. Abundance estimates will be calculated annually for white sturgeon larvae and fry in the Kootenai River, along with potential larval and young-of-the-year rearing habitat. These data will provide further insight into locations of spawning and rearing habitat and fish movements.

Juvenile white sturgeon abundance and distribution will be monitored with small mesh gill nets in the Kootenai River and Kootenay Lake. Relative abundance estimates will be calculated for juvenile fish using a sampling design based on location, time of year, gill-net sampling effort, and total catch. Potential juvenile rearing habitat will also be identified. Habitat use curves will then be prepared and compared to available aquatic habitat through the use of In-stream Flow Incremental Methodology (IFIM) (task 324). Knowledge of critical life-cycle requirements will be used to evaluate and direct habitat enhancement efforts.

324 Quantify sturgeon spawning/incubation habitat and early rearing habitat using In-stream Flow Incremental Methodology.

Habitat use data developed in tasks 321 through 323 will be used in the In-stream Flow Incremental Methodology model to quantify and locate spawning habitat and early rearing habitat in the Kootenai River system at different river discharge levels. This information will be used to evaluate the response of white sturgeon to habitat available during various flow regimes.

33 Conduct investigations on biological productivity in the Kootenai River.

Koocanusa Reservoir currently acts as a nutrient sink and thus limits the primary and secondary productivity of the Kootenai River downstream of

Libby Dam. Changes in nutrient availability affect the food chain for the fish community, the prey base for many species including white sturgeon, growth rates, and possibly survival of larval fish.

331 Assess the necessity of increasing nutrients in the Kootenai River.

Similar to the Kootenay Lake fertilization project previously described in Part I - Conservation measure 5, artificial additions of phosphorus and nitrogen may be a potential means of restoring primary and secondary productivity in the Kootenai River. All existing information regarding stream fertilization should be compiled and evaluated. Following this evaluation, a program describing potential nutrient dynamics and possible benefits to Kootenai River white sturgeon recovery from stream fertilization should be developed in cooperation with appropriate Canada, Montana, Idaho, and Indian Tribes. Improved primary and secondary productivity in the Kootenai River basin will also benefit other fish species, e.g. bull trout, rainbow trout, kokanee, burbot, and mountain whitefish.

332 Use computer modeling to refine and analyze recovery tasks.

In 1997, through a series of workshops, an Adaptive Environmental Assessment (AEA) model for the Kootenai River was developed as part of an adaptive management process to examine the potential benefits and impacts of alternate Kootenai River flow regimes on white sturgeon recruitment and other resources in the system. The main objective was to provide a tool that would aid in design of an experimental management program to define a flow regime that would benefit white sturgeon juvenile recruitment. The model simulations summarize the tradeoffs between power economics, flood protection, and fisheries benefits, as well as tradeoffs among species, associated with different flow regimes. The model will be used to evaluate the effectiveness of recovery tasks presented in this plan.

34 Evaluate the effects of contaminants on white sturgeon.

The Bonneville Power Administration funded a water and sediment quality study of the Kootenai River in the United States from Eureka, Montana downstream to Porthill at the United States/Canada border. However, lethal and sublethal effects of water and sediment chemical constituents on early life stages of white sturgeon still need to be determined.

341 Compile existing information on contaminants in the Kootenai River.

Use available information found in recent studies completed by the Kootenai Tribe of Idaho and Idaho State University to determine the presence and concentrations of contaminants including metals, organics, and inorganics in the water, sediment, and biota in the Kootenai River.

342 Conduct contaminant bioassays to evaluate the effects of selected chemicals on white sturgeon.

Laboratory studies of effects of heavy metals and other contaminants on white sturgeon eggs, larvae, and juveniles should be initiated. Existing protocols should be used where applicable; where no protocols exist, they should be developed with the cooperation of the Environmental Protection Agency.

4 Implement conservation and recovery of Kootenai River white sturgeon.

Recovery of Kootenai River white sturgeon is dependent upon regional coordination and adequate funding to implement conservation measures proposed in this plan.

41 Develop a Participation Plan to support implementation of the Kootenai River white sturgeon recovery plan.

Implementation of this recovery plan for Kootenai River white sturgeon will be accomplished only through interagency cooperation and participation leading to the timely recovery of the species while minimizing regional social and economic impacts. To meet these objectives, the Fish and Wildlife Service on July 1, 1994 issued new policy to develop a public Participation Plan for implementing recovery actions. Participation Plans are intended to ensure that a feasible recovery strategy involves and addresses the concerns of affected interest groups while providing realistic and timely recovery of the species. In the case of the Kootenai River white sturgeon, a Participation Plan would be developed by most of the agencies represented on the recovery team, and could include summaries of annual work plans for Kootenai River monitoring, research, and hatchery projects and section 7 consultations.

42 Identify funding required to achieve Kootenai River white sturgeon recovery.

Existing budgets of participating and responsible parties are not capable of funding all recovery tasks identified in this final plan. The recovery team should be retained to identify various funding strategies, including congressional appropriations, water-use fees, Federal mitigation programs, and binational agreements that may be useful in implementing white sturgeon recovery efforts.

421 Recommend research and management regarding ecosystem and fishery improvement measures for the Kootenai River basin.

As new information is developed and recovery actions are implemented, the recovery team should meet to address "new" research and management needs concurrent with white sturgeon recovery activities. The Fish and Wildlife Service anticipates that new questions and data needs will arise as white sturgeon recovery implementation occurs. The recovery team would meet to develop specific proposals to address these data gaps and recommend possible funding sources.

43 **Reevaluate downlisting and/or delisting criteria as needed.**

As initial recovery measures (see tasks 1-342) are accomplished and/or additional information regarding the ecology of Kootenai River white sturgeon becomes available, specific delisting criteria will be established.

44 **Determine the indirect recovery costs of foregone power generation.**

Implementing the many conservation actions proposed in this recovery plan may create additional economic impacts that are not normally considered a true "cost" of recovery. These impacts include foregone power generation opportunities, flood control impacts, and resident fish impacts.

The Army Corps of Engineers, Bonneville Power Administration, and BC Hydro should conduct an economic analysis of proposed white sturgeon recovery actions in terms of foregone power generation and remedial flood control requirements. This analysis should determine if the current "base economic assumptions" regarding lost power revenues are valid. The analysis should also consider alternative regional power marketing strategies to reduce revenue impacts and identify innovative measures to reduce potential flood control costs.

45 **Increase public awareness of the need to protect Kootenai River white sturgeon.**

Increase public awareness of the need to protect Kootenai River white sturgeon and their habitat (or ecosystem). Specific tasks to accomplish this might include periodic news releases, brochures, interactive presentations, in-school presentations by recovery team members, and possibly television documentaries.

5. Monitor the status of native fishes in the Kootenai River drainage.

The Kootenai River basin once provided important recreational, consumptive, and native subsistence fisheries. In addition to white sturgeon, residents and nonresidents fished for kokanee, burbot, rainbow trout, westslope cutthroat trout, bull trout, and mountain whitefish. All of these fisheries have declined dramatically over the past several decades. For example, a recent creel survey by the Idaho Department of Fish and Game revealed that fishing effort in the Idaho portion of the Kootenai River is the lowest of all waters surveyed in northern Idaho (Vaughn L. Paragamian, IDFG, pers. comm., 1996). Conversely, the abundance of nongame fish (e.g. suckers, northern squawfish) is three times higher than prior to the construction and operation of Libby Dam. Restoration of recreational fisheries is important to anglers and the regional economy.

Studies on the status of native fish in the Kootenai River basin were first authorized by the Northwest Power Planning Council in 1983. Although many of these studies continue, additional information is still needed on the status and important habitats required by several of the native and recreationally important fish species, including bull trout, kokanee, rainbow trout, burbot, and mountain whitefish. This information will also be useful to evaluate how resident fish are affected by conservation actions for Kootenai River white sturgeon.

51 Conduct studies on kokanee downstream from Libby Dam.

The Montana Department of Fish, Wildlife, and Parks; Idaho Department of Fish and Game; Kootenai Tribe of Idaho; and British Columbia Ministry of Environment, Lands, and Parks should continue annual monitoring to determine if kokanee entrained through Libby Dam during white sturgeon and salmon flow augmentation survive and contribute to downstream regional fisheries. Annual population estimates of kokanee would also be useful in determining whether increasing kokanee populations observed in recent years are affected by nutrient availability in the Kootenai River and Kootenay Lake.

511 Collect abundance, distribution, and reproduction data for kokanee in the lower Kootenai River tributaries.

Annual kokanee spawning population estimates will be determined. Information will be used to provide recommendations for improving kokanee spawning habitat and reintroducing kokanee in the Kootenai River tributaries. Additionally, the Idaho Department of Fish and Game; British Columbia Ministry of Environment, Lands, and Parks; and Kootenai Tribe of Idaho should evaluate opportunities to enhance spawning habitats in the Yaak River and Lake Creek.

52 Determine the status and distribution of burbot in the Kootenai River downstream of Kootenai Falls and Kootenay Lake.

Burbot are currently classified as a State threatened species by the Idaho Department of Fish and Game. The commercial and sport harvest of burbot prior to 1974 was estimated as high as 25,000 kilograms (55,000 pounds) in some years. This was primarily a winter fishery with few burbot caught in the spring and fall. Since that time, the burbot fishery in the Kootenai River basin has collapsed. There has been scant evidence of reproduction, only one juvenile burbot and no larvae have been captured in recent years. Sonic telemetry studies and recaptures reveal that the Goat River is the only known spawning location in the lower Kootenai River drainage (Paragamian et al 1997).

521 Determine distribution and life history of burbot.

The study begun in 1993 to identify distribution, life history, and factors limiting populations of burbot within the Kootenai River drainage should continue to be funded by the Bonneville Power Administration. All burbot captured will be tagged, and population estimates will be conducted annually to monitor population trends.

522 Determine secondary impacts from the flow augmentation program on burbot.

Recent research efforts by the Idaho Department of Fish and Game suggests that high, fluctuating Kootenai River flows during the winter affect winter migrations of burbot and possibly impact reproduction. Information garnered from implementing task 11 and completing task 521 should be used to evaluate how the proposed flow augmentation program will impact burbot recruitment. Preliminary study results indicate that burbot migrations during the spawning season may be effected by Libby Dam outflows during the winter for power production and flood control. Flow tests should be conducted to determine the maximum tolerable discharge and duration to allow burbot migration. This information is important because burbot in Idaho and British Columbia are genetically distinct from burbot in the Montana reach of the Kootenai River. Some believe this stock may be at greater risk of extinction than sturgeon.

53 Identify factors limiting rainbow trout survival and/or recruitment in the Kootenai River basin.

Rainbow trout spawning activity should be monitored to evaluate egg desiccation and/or redd scouring impacts in the Kootenai River from the white sturgeon flow augmentation program.

531 Determine the status, distribution, and habitat use of rainbow trout in the Kootenai River from Libby Dam to Bonners Ferry.

The Idaho Department of Fish and Game and the Montana Department of Fish, Wildlife, and Parks should further investigate the status and distribution of rainbow trout, including native Gerrard and interior redband, in the Kootenai River downstream of Libby Dam. Habitat use will be determined for fry, juvenile, and adult rainbow trout using scuba and snorkeling in the Kootenai River. This information will be useful to evaluate the effects of white sturgeon flow augmentation on rainbow trout.

54 **Develop information on bull trout in the Kootenai River basin.**

On June 10, 1998, the Columbia River population of bull trout was listed as a "threatened" species (63 FR 31647) under the Endangered Species Act. Additional information is needed on life history requirements, distribution, and factors regulating bull trout subpopulations within the Kootenai River drainage.

541 **Determine distribution and status of bull trout in tributaries of the Kootenai River.**

Bull trout are known from the Kootenai River, Koocanusa Reservoir, Kootenay Lake, and several tributaries within the Kootenai River basin. Bull trout are currently isolated into five subpopulations in the Unites States portion of the basin, with subpopulations generally stable with relatively low abundance. Monitoring by Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the Kootenai Tribe of Idaho will better describe the distribution, abundance, and habitat availability for bull trout. For example, bull trout surveys, including redd counts, should be conducted for all Montana streams where bull trout have previously been found, including Quartz, O'Brien, Libby, and Pipe Creeks and the Fisher River.

542 **Identify additional conservation measures to protect bull trout in the Kootenai River drainage in Montana, Idaho, and British Columbia.**

The Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the Kootenai Tribe of Idaho, using information garnered from task 541, should identify additional conservation measures necessary to maintain bull trout within the Kootenai River basin. Additionally, these agencies should evaluate whether recovery measures proposed for white sturgeon impact bull trout.

55 Conduct research on mountain whitefish in the Kootenai River from Libby Dam downstream to Bonners Ferry.

Habitat use will be determined for fry, juvenile, and adult mountain whitefish using SCUBA and snorkeling. If possible, separate use data will be obtained for winter, summer, and spawning habitat. Microhabitat measurements (e.g. depth, velocity, substrate, and cover) will be taken at locations where fish are encountered.

551 Determine the secondary effects of proposed white sturgeon flow augmentation on mountain whitefish.

A secondary effect of the white sturgeon flow augmentation program would be less water available during the winter when mountain whitefish spawn. In order to meet normally high, daily power demands during the winter, Libby Dam discharge fluctuations could possibly dewater and kill incubating mountain whitefish eggs. The Montana Department of Fish, Wildlife, and Parks and the Idaho Department of Fish and Game should monitor these potential impacts.

56 Evaluate impacts of flow augmentation on resident fish in Canada and the United States.

Flow augmentation proposals to benefit white sturgeon and salmon will result in water spill at Canadian Kootenay River dams. Additional monitoring is needed to evaluate the potential fisheries impacts on the Duncan, Arrow, and Koocanusa systems due to proposed recovery measures.

561 Effects of flow augmentation on total gas pressure in the Kootenay River and Columbia River downstream of Kootenay Lake.

Flow augmentation proposals to benefit white sturgeon will result in water spill at Canadian Kootenay River dams. This will increase total gas pressure levels to possibly lethal levels for some fish downstream of Brilliant Dam. Columbia Power Corporation, the Canada Department of Fisheries and Oceans, The British Columbia Ministry of Environment, Lands, and Parks, and Environment Canada should monitor these impacts, and consideration should be given to increasing hydroelectric capacity or using other gas reduction technology at Brilliant Dam as a means to mitigate these resident fish impacts.

562 Effects of flow augmentation on Kootenay Lake and on the Duncan and Arrow Reservoirs/Columbia River systems.

Potential fisheries impacts on the Duncan and Arrow reservoir systems due to white sturgeon flow augmentation from Libby Dam include 1) fluctuating flow releases from Duncan Dam during bull trout spawning migrations. This may affect bull trout movement and general spawning behavior; 2) decreased flow releases from Keenleyside Dam during rainbow trout spawning and rearing periods. This may reduce available spawning habitat and changes in temperature regimes due to flow changes, which may result in changes in incubation times; 3) decreased flow releases from Keenleyside may negatively effect staging and spawning of Columbia River white sturgeon; and 4) August releases from Libby Dam passing through Kootenay Lake and/or Arrow reservoir may flush nutrients and forage organisms from upper strata waters affecting overall biological productivity.

563 Evaluate effects of hydro peaking on native fish throughout the Kootenai River downstream of Libby Dam.

Daily load following and power peaking at Libby Dam may increase flows by fivefold in a few hours. These types of flows have altered the Kootenai River in the reach downstream from Bonners Ferry to Kootenay Lake to the extent that the river rarely freezes during the winter. These practices may particularly be impacting bull trout in the vicinity of Libby Dam in Montana and burbot in Idaho. Evaluations as part of tasks 51, 52, 53, 54, and 55 should include the effects of load following and power peaking.

564 Evaluate measures to reduce risk to native and resident sport fish below Libby Dam.

Demand for refill at Libby Dam for salmon recovery efforts, white sturgeon recovery, and sport fishing interests may lead to less conservative flood rule curves at Libby Dam in the 85- to 100-year protection range proposed in the original project justification. This would result in increasing the risk of spill and injury to bull trout and other native or resident sport fish since the frequency of "unregulated" spill will increase. The Army Corps of Engineers; Bonneville Power Administration; Montana Department of Fish, Wildlife, and Parks; and the Fish and Wildlife Service should evaluate "flip lips" and other structures that could minimize fish injuries and gas supersaturation downstream of Libby Dam.

6 Assess the overall success of implementation of the recovery plan and revise accordingly.

This plan should be updated on a 5-year basis as recovery tasks are accomplished, or revised as environmental conditions change and/or monitoring results or additional information becomes available.

The recovery team should meet annually to review annual monitoring reports and summaries and make recommendations to the Fish and Wildlife Service to revise the Plan.

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PART III - IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows describes recovery task priorities, task numbers, task descriptions, duration of tasks, potential or participating responsible parties, and lastly, estimated costs, if available. These tasks, when accomplished, will contribute to recovery of the Kootenai River population of white sturgeon as discussed in Part II of this Plan.

Parties with authority, responsibility, or expressed interest to implement a specific recovery task are identified in the Implementation Schedule. Listing a responsible party does not imply that prior approval has been given or require that party to participate or expend any funds. However, willing participants will benefit by demonstrating that their budget submission or funding request is for a recovery task identified in an approved recovery plan, and is therefore part of a coordinated recovery effort to recover the Kootenai River population of white sturgeon. In addition, section 7(a)(1) of the Endangered Species Act directs all Federal agencies to use their authorities to further the purposes of the Act by implementing programs for the conservation of threatened or endangered species.

Other physical and economic impacts from recovery

Implementing the many conservation actions proposed in this recovery plan will create additional economic or environmental impacts, and also associated benefits, not normally considered in estimating the "costs" of recovery. Economic and environmental impacts include foregone power generation opportunities, flood control impacts, and resident fish impacts.

- Flood control impacts can include agricultural and residential flooding, groundwater seepage, and pumping costs. For example, crop losses ranging from 30 to 100 percent of a total 650 acres on 12 farms in the United States portion of the Kootenai Valley were attributed to the 1995 white sturgeon/salmon recovery flows (Dave Wattenburger, Boundary County Extension, *in litt.* 1996). The value of crop losses has not been estimated to date. Some farmlands were inundated, others were yellowed through soil saturation, and other lands were inaccessible during the growing season for weed control activities. Irrigation drainage pumping costs for the period May 1 through July 15, 1995 were estimated at $19,325 in the same United States portion of the Kootenai Valley. This cost will be adjusted downward when baseline pumping costs for ongoing average pumping needs are provided.

- Nontargeted Fish impacts. Flow augmentation proposals to benefit white sturgeon and salmon will result in water spill at Kootenay River dams, in Canada. This will increase total gas pressure levels to possibly lethal levels for some fish downstream of Brilliant Dam. Impacts should be monitored and consideration should be given to increasing hydroelectric capacity or using other gas reduction technology at Brilliant Dam as a means to mitigate these impacts on resident fish.

  Potential fisheries impacts on the Duncan and Arrow Reservoirs and Columbia River systems due to white sturgeon flow augmentation from Libby Dam include 1) fluctuating water releases from Duncan Dam during bull trout spawning migrations, which may affect bull trout movement and general spawning behavior; 2) decreased water releases from Keenleyside Dam during rainbow trout spawning and rearing periods, which may reduce available spawning habitat and changes in temperature regimes due to flow changes may result in changes in incubation times; and 3) decreased water releases from Keenleyside, which would negatively effect staging and spawning of Columbia River white sturgeon.

Associated benefits include the partial restoration of a more natural Kootenai River hydrograph and flood plain function that benefit resident fish and wildlife. Periodic flushing flows would cleanse Kootenai River gravels and improve insect production. Improving the aquatic ecosystem health leading to improved regional fisheries will provide secondary economic benefits to local communities. Such benefits go beyond the "benefits" typically considered in recovery actions. Conversely, failure to implement proposed recovery actions would have hidden environmental costs that are typically not considered in cost/benefit analysis.

Following are definitions to column headings and keys to abbreviations and acronyms used in the Implementation Schedule:

Priority No.: All priority 1 tasks are listed first, followed by priority 2 and priority 3 tasks.

Priority 1: Actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: Actions that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery (or reclassification) of the species.

Task Number and Task Description: Recovery tasks as numbered in the recovery outline. Refer to the Narrative for task descriptions.

Task Duration: Expected number of years to complete the corresponding task. Study designs can incorporate more than one task, which when combined, can reduce the time needed for task completion.

Responsible or Participating Party: Federal, State, Tribal, or Canadian government agencies, nongovernment organizations, or universities with responsibility or capability to fund, authorize, or carry out the corresponding recovery task.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
1	111	Conduct public review of and approve new operational guidelines for Libby Dam.	1	USACE*, MFWP, FWS, BPA, DFO, MELP	120	40	80				Begin in 1999
1	112	Implement new operational guidelines to provide annual flow regimes to benefit white sturgeon in the Kootenai River basin.	Continual	USACE*, BPA, MFWP, FWS	Unk						Costs include foregone power production; possible flood control costs, need to be determined.
1	113	Coordinate Libby Dam flow releases during April through August to achieve an optimum combination of water temperature and discharge volume.	Continual	USACE, BPA, BR, NMFS, FWS, MFWP, BC HYDRO	Unk						Instream management to fine-tune augmentation
1	114	Store water in Koocanusa Reservoir prior to spring runoff to achieve white sturgeon flow targets.	Ongoing	USACE*, BPA, MFWP	Unk						
1	115	Conduct agency coordination for implementing white sturgeon flow augmentation program.	Ongoing	USACE, BPA, BC HYDRO DFO, MELP, MFWP, IDFG	15	3	3	3	3	3	U.S./Canada coordination.
1	116	Kootenay Lake Evaluations.	Ongoing	USACE, MELP, FO, BPA, USFW	Unk		Unk				
1	117	Evaluate alternatives increasing peak Kootenai River flows.	Continual	DFO, BPA, USFWS	Unk			Unk			
1	118	Use existing authorities to conserve and restore Kootenai River white sturgeon.	Continual	USACE, FWS BPA, NMFS	Unk						Section 7 consultation on Libby Dam operations.
1	121	Monitor potential residential or agricultural flooding, levee erosion, and groundwater seepage resulting from flow augmentation.	Ongoing	USACE	Unk						Concurrent with Task 112.
1	122	Identify opportunities to restore natural floodplain functions along the Kootenai River.	Ongoing	USACE* NRCS, DFO MELP	Unk						
1	123	Develop public information program to explain USACE past and current flood control compensation program.	1-2	USACE	Unk	Unk	Unk				1 - 2 year public information program.
1	124	Monitor impacts of flow augmentation on Kootenai River levees and Kootenay Lake in British Columbia.	Continual	DFO, MELP	Unk						New monitoring program may be needed.
1	125	Assess consolidation of white sturgeo spawning and incubation, habitat quality, and potential substrate improvement measures.	1-2	FWS, IDFG, KTOI	***						Funded as part of Task 321

* - Lead Agency
*** - Costs associated as part of other recovery tasks.

unk - Cost estimates are unknown.
ongoing - Task is currently being implemented.
continual - Task will be implemented annually when approved and/or funded.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
1	211	Obtain necessary local, State, Tribal, Federal, and Canadian approval and permits for all conservation aquaculture activities.	Continual	IDFG, KTOI, FWS, MFWP	Unk						Need to obtain permits annually e.g. Section 10.
1	221	Determine water quality standards for KTOI Hatchery.	1	BPA, KTOI* MFWP	***						1 year, as part of Task 224
1	222	Upgrade KTOI hatchery to meet conservation aquaculture objectives.	2 - 3	BPA, KTOI,	1711						Complete upgrade begun in 1998. Cost accrued beginning in 1998.
1	223	Maintain Kootenai Trout trout hatchery as a secondary rearing facility.	1	BPA, MFWP	310	61	62	63	62	62	Contract costs part of dollars allocated as part of task 222
1	224	Implement the conservation aquaculture program.	10	BPA, KTOI,	1300	240	290	260	270	280	Costs of operating existing KTOI hatchery, out year costs be higher if hatchery is expanded
1	231	Use adopted white sturgeon broodstock collection protocol.	10	BPA, KTOI,* IDFG	***						Funded as part of Task 224
1	232	Collect adequate numbers of male and female broodstock to maintain the genetic quality.	10	BPA, KTOI, IDFG	***						Funded as part of Task 224.
1	233	Annually evaluate the conservation aquaculture program.	10	BPA, KTOI IDFG, MFWP	***						Funded as part of Task 224 will be evaluated annually.
1	241	Evauate appropriate production goals	Continual	KTOI, BPA, FWS, MFWP, IDFG, DFO, MELP	***						Funded as part of Task 224
1	242	Develop a fish health plan for hatchery	Continual	KTOI*, ALL AGENCIES	***						Funded as part of Task 224
1	243	Develop tagging protocols for hatchery reared white sturgeon.	2	KTOI, IDFG*, DFO, MELP, MFWP	Unk	Unk	Unk				Funded as part of Task 224
1	245	Evaluate feasability of establishing an experimental white sturgeon population outside of the current occupied range.	2	ALL AGENCIES	***						Recovery team will consult with State and Canada agencies.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
1	25	Release hatchery reared white sturgeon into the Kootenai River basin.	10	KTOI*, ALL AGENCIES	Unk						Funded as part of Task 224
1	251	Adjust white sturgeon releases as necessary, to meet objectives of the Kincaid breeding plan.	10	KTOI, FWS, MFWP, BPA	***						Funded as part of Task 224
1	261	Determine factors limiting production (natural and hatchery) and habitat use patterns for each life history stage.	Ongoing	BPA, KTOI, MFWP, IDFG	Unk						Funded as part of Task 321
1	321	Describe response of spawning white sturgeon to various Kootenai River flows, water temperatures, and Kootenay Lake elevations.	Continual	KTOI, MELP MFWP, IDFG, NMFS	4000	750	775	800	825	850	120 K of this total is for monitoring effects of augmentation in Kootenai Reservoir
1	322	Measure white sturgeon spawning annually.	Continual	IDFG, KTOI, MFWP	Unk						Funded as part of Task 321
1	323	Measure white sturgeon larval, fry, and juvenile abundance and distribution in the Kootenai River and Kootenay Lake annually.	Continual	BPA, IDFG, KTOI, MFWP	Unk						Funded as part of Task 321
1	41	Develop a Participation Plan to support implementation of the Kootenai River white sturgeon recovery plan.	1	ALL AGENCIES	Unk		Unk				Will be completed as part of final recovery plan.

RECOVERY PLAN IMPLEMENTATION SCHEDUAL
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
2	244	Develop a policy for hatchery white sturgeon produced in excess of beneficial uses identified in this plan.	1	BPA, FWS, KTOI, IDFG, MFWP, DFO, MELP	***	Unk					May require need for Section 10 permits. Funded as part of Task 223.
2	311	Sample adult and juvenile white sturgeon in the Kootenai River and Kootenay Lake.	Ongoing	BPA, KTOI, MFWP, IDFG BC, MELP	***						Funded as part of Task 321.
2	312	Collect and preserve tissue and blood samples for genetic analysis. system.	Ongoing	BC, MELP BPA, KTOI, MFWP, IDFG	***						Funded as part of Task 321.
2	313	Compile catch data to refine white sturgeon population size estimates annually in the Kootenai River basin.	Ongoing	BPA	***						Funded as part of Task 321.
2	314	Develop a juvenile white sturgeon year class index.	2	BPA, IDFG*	***	Unk	Unk				Funded as part of Task 321.
2	323	Measure white sturgeon larval, fry, and juvenile abundance and distribution in the Kootenai River and Kootenay Lake annually.	Ongoing	BPA	***						Funded as part of Task 321.
2	324	Quantify sturgeon spawning incubation habitat and early rearing habitat using IFIM.	2	BPA, IDFG, KTOI, MFWP	***		Unk	Unk			Begin in 1997, funded as part of Task 321.
2	331	Assess the necessity of increasing nutrients in the Kootenai River.	5	BPA, KTOI	***						Funded as part of task 321.
2	332	Use computer modeling to refine and analyze recovery tasks	1	USFWS, MELP, IDFG, KTOI	Unk	Unk					Either 1996 or 1997.
2	341	Compile existing information on contaminants in the Kootenai River.	2	BPA, KTOI* IDFG	Unk	Unk	Unk				Funded as part of Task 331.
2	342	Conduct contaminants bioassays to evaluate the effects of selected chemicals on white sturgeon.	5	BPA, KTOI*	Unk						Part of recovery Task 331
2	421	Recommend additional research and management regarding ecosystem and fishery improvement measures for the Kootenai River Basin.	Ongoing	Recovery Team	Unk						Ongoing as needed.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
3	44	Determine the indirect recovery needs of foregone power generation	Ongoing	BPA, USACE, BCHYDRO	Unk						
n/a	511	Collect baseline abundance, distribution, and reproduction data for kokanee in Idaho Kootenai River tributaries.	5	IDFG, KTOI MFWP	809	147	155	162	169	176	Ongoing
n/a	521	Determine distribution and life history of burbot.	5	IDFG*, MFWP	735	133	140	147	154	161	Ongoing
n/a	522	Determine secondary impacts from proposed flow augmentation program on burbot reproduction.	2	IDFG*, MFWP	Unk	Unk					Costs part of Task 521.
n/a	531	Determine the status, distribution, and habitat use of rainbow trout in the Kootenai River from Libby Dam to Bonners Ferry.	5	IDFG, MFWP	900	170	175	180	185	190	Ongoing
n/a	541	Determine distribution and status of bull trout in in tributaries of the Kootenai River.	2	IDFG*, MFWP	300	54	57	60	63	66	Started in 1996, ongoing
n/a	542	Identify additional conservation measures to protect bull trout in the Kootenai River drainage in Montana, Idaho, and B.C.	1	BPA, MFWP IDFG	Unk			Unk			Using results from Task 541.
n/a	551	Determine the secondary effects of proposed white sturgeon flow augmentation on mountain whitefish.	4	BPA, MFWP	75	13	14	15	16	17	
3	561	Effects of flow augmentation on TGP in the Kootenay River and Columbia River downstream of Kootenay Lake.	?	DFO, MELP	Unk						Canada projects
3	562	Effects of flow augmentation on the Duncan and Arrow Reservoir/Lower systems	?	DFO, MELP	Unk						Canada projects.
3	6	Assess the overall success of implementation of the recovery plan and revise accordingly.	Ongoing	Recovery Team	Unk						

PART IV. APPENDICES

Appendix A. Current fish fauna of the Kootenai River basin.

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Appendix C. Kootenai basin integrated rule curves and tiered approach for white sturgeon flow release from Libby reservoir.

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APPENDIX A. Current fish fauna of the Kootenai River basin. An asterisk (*) precedes the name of nonnative taxa.

Acipenseridae	
Acipenser transmontanus	white sturgeon
Salmonidae	
Coregonus clupeaformis	lake whitefish
Oncorhynchus clarki lewsii	westslope cutthroat
Oncorhynchus clarki clarkii	coastal cutthroat
Oncorhynchus nerka	sockeye salmon/kokanee
Oncorhynchus mykiss spp.	redband/rainbow trout
Prosopium williamsoni	mountain whitefish
Prosopium coulteri	pygmy whitefish
Salvelinus confluentus	bull trout
* *Salvelinus fontinalis*	brook trout
Cyprinidae	
Couesius plumbeus	lake chub
Mylocheilus caurinus	peamouth
Ptychocheilus oregonensis	Northern pike minnow
Richardsonius balteatus	redside shiner
Rhinichthys cataractae	longnose dace
Rhinichthys falcatus	leopard dace
Rhinichthys osculus	speckled dace
Catostomidae	
Catostomus catostomus	longnose sucker
Catostomus macrocheilus	largescale sucker
Ictaluradae	
* *Ameiurus melas*	black bullhead
Gadidae	
Lota lota	burbot
Centrarchidae	
* *Lepomis gibbosus*	pumpkinseed
* *Mircopterus salmoides*	largemouth bass

Percidae	
* *Perca flavescens*	yellow perch
Cottidae	
Cottus asper	prickly sculpin
Cottus cognatus	slimy sculpin
Cottus rhotheus	torrent sculpin

Appendix B:

EXAMINATION OF THE EFFECTS OF TWO ALTERNATIVE FLOW AUGMENTATION STRATEGIES ON THE KOOTENAI RIVER ECOSYSTEM

Prepared by the
Kootenai River White Sturgeon Recovery Team

June 1998

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INTRODUCTION

The construction and operation of dams has negatively effected the physical and biological environments of many aquatic and riparian organisms throughout the Columbia River Basin. Effects have been documented from the headwater reservoirs downstream to the mouth of the Columbia and its estuary. Direct effects include altering natural stream hydrology, impeding or isolating fish spawning migrations, and direct mortality of fish. Operation has historically been dictated by potentially conflicting demands of power generation, flood control, navigation, irrigation and other human concerns. Environmental changes have contributed to major declines of fisheries resources throughout the Columbia system. Numerous fish populations have been listed as threatened or endangered under the Endangered Species Act (ESA), including Snake River chinook and sockeye salmon, several steelhead ESU's and Kootenai River white sturgeon. More recently however, dam operations at many main stem Columbia River dams have been altered in response to the needs of dwindling fish populations in the Columbia River Basin.

In 1995, two Federal agencies issued Biological Opinions for Columbia River dam operations including operating requirements for Libby Dam. Libby Dam impounds the Kootenai River system which originates in British Columbia, Canada (spelled Kootenay) and flows through the states of Montana and Idaho, before flowing north back into Canada. The U.S. Fish and Wildlife Service issued a Biological Opinion on these operations for the endangered Kootenai River white sturgeon (*Acipenser transmontanus*), five Snake River snails and bald eagles (USFWS 1994), while the National Marine Fisheries Service published their Biological Opinion for endangered salmon in the Snake River (NMFS 1995). Operations requested by these plans are similar, but they differ sufficiently relative to summer flow augmentation for the Kootenai River to warrant further examination.

PURPOSE

This paper analyses the relative effects of two Kootenai River flow augmentation strategies developed for listed Snake River salmon and Kootenai River white sturgeon: 1) KIRC/VARQ; and 2) the NMFS 1995 Biological Opinion operation for Snake River salmon (NMFS 95 BiOp). Results of this analysis were used to develop a preferred flow alternative to help recover endangered Kootenai River white sturgeon while improving system health for riverine species in the Kootenai River and the Columbia River drainage downstream.

BACKGROUND AND ACTIONS TO DATE

Prior to dam construction, the Kootenai River flowed freely with high spring flows averaging 61 kcfs (up to 114 kcfs). The natural annual flow hydrograph sustained the aquatic ecosystem, which included the Kootenai River white sturgeon and native westslope cutthroat (*Oncorhynchus clarki lewisi*), bull trout (*Salvelinus confluentus*), interior redband trout (*Oncorhynchus mykiss* subspecies), and burbot (*Lota lota*). The typical hydraulic cycle in the headwaters of the Columbia River included a high flow event during the spring melt (late May through early June) and a stabilized low flow period throughout the remainder of the year (Parrett and Hull 1985). Adult white sturgeon, cutthroat and redband, migrated upstream in the Kootenai River during the spring runoff to spawn. White sturgeon adults broadcast their eggs over clean cobble (McCabe and Tracy 1993; Parsley et al. 1993; Palmer et al. 1988). Trout constructed redds by burying their eggs in clean, unembedded gravels in the main stem Kootenai and tributary streams. Their progeny incubated and emerged after the spring melt when flows were naturally declining. In the Kootenai River, native riverine fauna adapted and persisted under natural annual water temperature and discharge regimes. Associated species assemblages in the Kootenai River Basin co-evolved in relative isolation since the Wisconsin ice age (about 10,000 years ago).

The white sturgeon population of the Kootenai River is now endangered (59 FR 45989, September 6, 1994). The fall spawning bull trout are included in the Columbia River population segment listed as threatened under ESA on June 10, 1998 (63 FR 31647). Westslope cutthroat, interior redband and burbot populations of the Kootenai River have also declined and are being closely monitored across their range (Partridge 1983, Anders 1993, Paragamian 1994, and Paragamian et al. 1996).

Natural riverine processes in the Kootenai River have been disrupted by the construction and operation of Libby Dam beginning in the mid-1960s. The dam was completed in 1972 and the pool filled for the first time in 1974. During the 1970s and 1980s, the annual schedule at Libby Dam captured the spring runoff until the reservoir approached full pool in July. The dam discharge was typically held to the minimum flow of 4,000 cubic feet per second (cfs) while the reservoir filled (mid April through mid July). Full pool is achieved at elevation 2459 feet above mean sea level. When the pool reaches the annual maximum refill, the dam discharge is controlled to approximate the inflow volume and the pool elevation remains stable. During late fall and winter, the reservoir is normally drafted for power generation and flood control. Reservoir storage released for these purposes causes flows to be above natural (pre-dam) levels during the historic low flow period. The reservoir reaches minimum capacity by mid-April, and the cycle is repeated annually. Dam operation has essentially reversed the natural hydrograph (Partridge 1983). Figure 1 shows the effect of Libby Dam operation on Kootenai River flows. Evidence suggests that river flow and water temperature influence the movements and reproduction of native species, including white sturgeon .

As dams were installed on many Columbia River tributaries, the overall storage capacity of the Columbia River system increased, and spring flows were diminished. Loss of the spring freshet is believed to be a primary factor in the decline of anadromous and resident fish populations in the Columbia River basin (ISG 1996, Apperson 1992, and Apperson and Anders 1991).

To partially address this problem, the USFWS in the 1995 Biological Opinion requested increased flows from Libby Dam during spring and early summer to aid the natural reproduction of the estimated 1,000-1,500 remaining adult Kootenai River white sturgeon.

Similarly, the NMFS Biological Opinion requested a more natural spring freshet to enhance the downstream movement of endangered Snake River salmon juveniles (smolts). Both plans attempt to reestablish a naturalized spring freshet, as limited by established flood control criteria, to create a more natural annual hydrograph in the Kootenai River. A portion of the water flowing into Libby Reservoir during spring is passed through Libby Dam to create a flow pattern as similar as possible to one which white sturgeon and other species in the Kootenai River adapted and co-evolved. The primary significant difference between the two Biological Opinions is that the NMFS plan calls for increased discharge during August to aid the downstream migration of salmon smolts.

The Kootenai River White Sturgeon Recovery Team (Team), established in 1995, recognized the importance of Libby Dam operations to the health and persistence of several fish populations listed under ESA in the Columbia River system (Table 1) as well as those species not currently listed. The Team adopted a new, adaptive management approach for Kootenai River flow management that was designed to balance power generation and flood control with concerns for white sturgeon, salmon and other resident fish populations. This approach, known as the Kootenai Integrated Rule Curve/Tiered Flow Approach (KIRC) incorporates flow releases from Libby Dam designed to promote natural reproduction of white sturgeon. According to this approach, Libby Dam discharge volume is determined as a function of the inflow volume to Libby Reservoir (Lake Koocanusa). The KIRCs are a mathematical tool to improve spring flow augmentation without compromising reservoir refill probability. The KIRCs provide for the needs of resident and anadromous fish species from a watershed

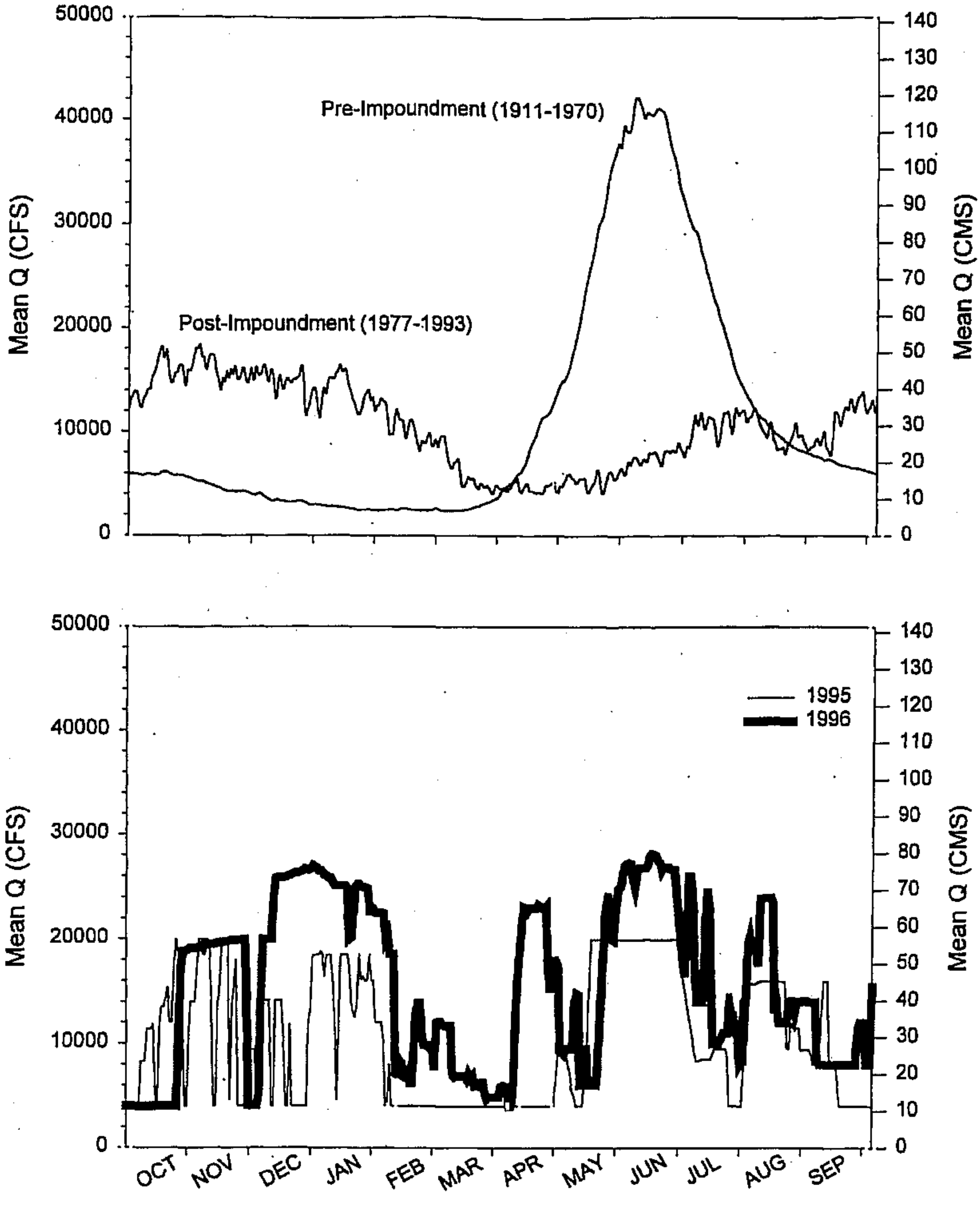


Figure 1. Effect of flow regulation on the annual hydrograph of the Kootenai River. Top chart compares the pre-dam condition to regulated flows prior to modifications for sturgeon. Bottom chart shows the effect of recent modifications for fisheries concerns.

perspective. Under this plan, system flood control is partially defined by a new strategy developed by the U.S. Army Corps of Engineers (ACOE) called VARQ (ACOE 1997). This "variable flow" flood control strategy allows greater flexibility for balancing upstream and downstream fisheries concerns. The KIRC and VARQ are identical during the period April 1 through July 30 when inflows are average (100 percent of normal) or greater. VARQ allows higher reservoir elevations than the KIRC during below average water years, which allows additional water storage (above the KIRCs) prior to spring runoff. During dry years (lowest 20 percent), stored water can be used to augment spring outflows without compromising reservoir refill probability. Henceforth in this document, the KIRCs with the VARQ flood control strategy will be referred to as KIRC/VARQ. This more natural discharge pattern for Libby Dam and the downstream river system was unanimously supported by the Team members as a key task in the draft and final draft Kootenai River White Sturgeon Recovery Plan.

Table 1. Current list of petitioned, proposed or listed aquatic species in the Columbia River basin.

- Steelhead trout, **listed** as threatened or endangered by ESU, August 2, 1997 (62 FR 43937)
- Bull trout, **listed as** threatened-Columbia River population segment June 10, 1998 (63 FR 31647).
- Snake River spring and fall chinook salmon, **listed** as threatened, April 22, 1992 (57 FR 14653)
- Snake River sockeye salmon, **listed** as endangered, November 20, 1991 (56 FR 58619)
- Westslope cutthroat trout, **petitioned** to be listed, June 1997, 90-day finding for an amended petition to **list** as threatened June 1, 1998 (63 FR 31691).
- Coho salmon, southern Oregon/Northern California Coast ESU, listed as threatened, May 6, 1997 (62 FR 24588)
- Kootenai River white sturgeon, **listed** as endangered, September 6, 1994 (59 FR 45989)
- Five Snake River snails, 4 **listed** as endangered and **listed** as threatened, December 14, 1992 (57 FR 59244)

In general, flow levels recommended by the Team (KIRC/VARQ flows) and by NMFS 95 BiOp are compatible throughout most of the operating year, but differ substantially during July and August. Fundamental differences in flow requests sparked heated debate which led to at least one congressional hearing (Senate Subcommittee on Science, Technology, and Space, June 19, 1996). A technical analysis of Columbia River operating criteria, funded by NMFS and BPA, was initiated to find common ground and develop a compromise (Wright 1996). The analysis compared the IRC concept (an earlier version of the KIRC) to the NMFS Biological Opinion, and two other alternatives. This analysis used a modified version of our Alternative 1 with existing ACOE flood constrains, not VARQ. In this scenario, lower reservoir elevation for flood control resulted in reduced storage for flow augmentation in dry years. Incremental tradeoffs between anadromous and resident fish species were not addressed. Instead, Wright and others (1996) focused the debate by identifying similarities and differences in dam operations described by the alternatives. Wright (1996) determined that the primary differences between the IRCs and NMFS Biological Opinion are: (1) the volume of reservoir water released during spring in years of low reservoir recharge; (2) the amount of flow augmentation and reservoir drawdown during late summer; and (3) resulting reservoir refill probability and summer elevations. The VARQ modification improves spring flows during dry years and increases reservoir refill probability (1 and 3 above).

During dry years in the Kootenai sub-basin, the KIRC/VARQ tiered flow approach would provide only a minimal spring freshet for white sturgeon, additional flow augmentation is possible using the VARQ strategy. Conversely, the NMFS Biological Opinion would draft the reservoir to attempt to meet flow targets in the lower Columbia in all years. Whereas the KIRC/VARQ attempts to fill Libby Reservoir in July and maintain the pool elevation near full, the NMFS Biological Opinion, in attempting to meet a minimum flow target of 200 kcfs at McNary Dam, drafts the reservoir 20 feet below full pool by the end of August. As a result, the reservoir refill probability is significantly reduced (by as much as 35 percent) as flows are increased downstream.

This paper examines relative effects of these operational strategies on the physical and biological condition of the Kootenai River system in the context of the entire Columbia Basin in the U.S. and Canada. The physical environment, flood plain function and biological responses were assessed relative to natural, pre-dam conditions. The analysis focuses on Libby Reservoir and the Kootenai River downstream to Kootenay Lake. Empirical evidence and previous analyses were used when available. Impacts to Kootenai white sturgeon are described based upon knowledge pertaining to the species in the Kootenai River and across its range.

DESCRIPTION OF ALTERNATIVE FLOW AUGMENTATION STRATEGIES

Alternative 1: The Kootenai Integrated Rule Curve/Variable Discharge Flood Control VARQ - No Summer Flow Augmentation

The Kootenai Integrated Rule Curves are a mathematical tool designed for Libby Dam water management to balance the requirements of power generation and flood control with resident and anadromous fish (Marotz et al. 1996). The curves are a family of operational rules for dam operation that incorporate incremental adjustments to allow for uncertainties in water availability. Libby Dam operation is determined based on inflow forecasts and constrained by the physical character of the dam and drainage basin. The first inflow forecast of the year becomes available in early January. Upon receipt of the forecast, the dam operator follows a drawdown schedule as dictated by the KIRC/VARQ corresponding with that forecasted inflow volume. Upon receipt of forecasts (February through June), the operator would adjust the elevational target to the new curve corresponding with the updated subsequent monthly inflow volume. This causes the actual operation to be flexible and variable over the operating season, yet predictable based on reservoir inflow forecasts. Actual operations will vary somewhat from the target elevations due to inflow forecasting error and unpredictable precipitation events. The curves were designed to limit the duration and frequencies of deep reservoir drawdowns, increase the frequency of reservoir refill, and produce a more natural discharge hydrograph in the Kootenai River downstream from Libby Dam.

The KIRCs delay the date of refill during high water years to reduce the potential for emergency use of the spillway. Forced spill caused by high pool elevations and/or excessive reservoir inflows, and gas supersaturation associated with spill in the Kootenai River, are thus avoided. Once full, Libby Reservoir remains at the maximum elevation through September 15. Inflowing water is passed through the dam, creating a gradual decline in discharge which mimics the natural flow regime.

The VARQ hydrology and strategy for system flood control was developed and critically examined by the ACOE Hydraulics Branch (ACOE 1997). Hydraulic modeling indicates that the operations defined by VARQ are nearly identical to the KIRCs during average to medium high water years. VARQ requires slightly deeper (5 to 10 feet) drawdown for flood control in the highest 10 percent of water years. For modeling purposes, the KIRCs were modified in high water years to be consistent with VARQ, resulting in the hybrid KIRC/VARQ. During below normal water conditions, VARQ allows higher reservoir elevations than described by the KIRCs which integrate power operations (and thus result in lower elevations). VARQ allows additional water to be stored prior to spring runoff in drier years (less than 100 percent normal inflow to Libby Reservoir), enabling greater discharges during spring while maintaining reservoir refill probability.

The KIRC alternative was designed to gradually ramp down from the spring peak to reduce flow fluctuations. During dry years, the maximum drawdown of the reservoir was reduced consistent with the NMFS 95 BiOp and VARQ to increase the volume of pass-through flows during spring runoff. The reservoir refill trajectory was reshaped to normalize the discharge. In wetter years, the discharge was smoothed to further extend the descending limb of the hydrograph. The alternative was designed to gradually ramp down from the spring peak to reduce flow fluctuations.

Alternative 2: NMFS 1995 Biological Opinion - 20 foot Reservoir Draft during August to Augment Summer Flows Downstream

The NMFS Biological Opinion specifies meeting the April 20 upper flood control rule curve (75 percent of the time) at Libby Dam to increase reservoir storage just prior to spring runoff (similar to VARQ). The intent is to provide higher spring flows as less water is required for reservoir refill. Reservoir refill may be sacrificed to meet downstream flow targets at McNary Dam in lower water years (less than 100 percent "normal" Columbia River flows defined as an annual flow volume less than 105.9 MAF at the Dalles).

The August releases called for by the NMFS Biological Opinion are designed to aid the migration of juvenile Snake River salmon as they pass through dams in the lower Columbia River. The NMFS Biological Opinion calls for maximum Libby Dam discharge (of up to 27 kcfs) during August until Libby Reservoir is drafted to 20 feet from full pool. Water from two headwater storage projects, Libby and Hungry Horse, is released to augment the natural flows in the Columbia River to meet a summer flow target of 200,000 cfs at McNary Dam. The goal is to increase water velocities in the pools upstream from dams in the lower Columbia to reduce particle travel times, a surrogate for fish movement, and ultimately to aid the migration of juvenile salmon toward the ocean.

This alternative produces an unnatural flow fluctuation in the Kootenai River during the productive summer months. Extreme reductions in flow between the discharge peaks cause large expanses of productive riffle habitat to become dewatered, reducing biological productivity in the affected river reach and subsequently downstream as well. These discharge fluctuations could be moderated by delaying the date of reservoir refill or by extending the period of flow augmentation. This strategy increased the risk of reservoir refill failure, which reduces biological productivity in the reservoir and causes the reservoir to begin the following year at a deficit, thus affecting the sustainability of the operation.

METHODS

Hydrologic Modeling

Operations specified by the NMFS Biological Opinion were provided by Bonneville Power Administration's Dittmar Control Center, Study 98C_01.OPERB (Roger Schiewe BPA and Michael Newsom NMFS, personal communication). Libby Reservoir elevation data were received electronically in a 50-year matrix (August 1929 through July 1978). Annual data represented 14 end of period elevations (monthly data with April and August split into half-month periods). Consecutive years were appended, then adjusted to perform simulations on a water year basis (October 1 through September 30).

To simplify visual comparisons of the three alternatives, we overlayed plots of resulting operations from low, average and high water years. Corresponding annual volumes of inflow to Libby Reservoir are: low inflow (6.068 Million Acre Feet [MAF], 75 percent normal), average (8.088 MAF, 100 percent normal) and high inflow (>10.110 MAF, 125 percent normal). A representative NMFS 95 BiOp operation for low, average, and high water years was constructed by selecting five or more years with inflows approximately equal to the specified annual inflow volumes ($\pm$ 0.5 SD), then calculating the mean elevation for each of the 14 periods. It was necessary to create these composite operations to mask the effect of differences in water availability in the main stem Columbia relative to the Kootenai sub-basin (i.e. water availability in the Kootenai system varies somewhat independently from water availability in the lower Columbia River). Years included in the composite operations are as follows:

Water Availability	Water Year	Annual Inflow (MAF)
High	1956	10.863
	1934	10.658
	1959	10.496
	1969	10.068
	1976	9.785
Medium	1963	8.101
	1953	8.088
	1935	8.046
	1932	8.017
Low	1929	6.259
	1970	6.179
	1940	6.014
	1936	5.974
	1945	5.904

Study 98C assumed that storage reservoirs would only be drafted to 20 feet below full pool in August if the seasonal target (July 1 through August 31) of 200 thousand cubic feet per second (kcfs) at McNary Dam was not met. This assumption resulted in varying degrees of reservoir drafting (0 to 20 feet from full pool during August) throughout the 50-year record, and caused the composite data to underestimate the effect of summer flow augmentation (a reservoir draft to 20 feet from full pool) as specified by the NMFS 95 BiOp. The NMFS 95 BiOp, p. 102, also states: "The TMT [Technical Management Team] may recommend lower summer reservoir elevations if necessary to meet [salmon] flow objectives depending on the circumstances of the runoff and the salmon migration (e.g., [sic] a low water year that is one in a series of low water years and an outmigrating population of fish that represents a strong year class)." This decision process could not be modeled in this analysis.

The KIRC/VARQ operations used for comparison were generated using the quantitative reservoir model LRMOD (Marotz et al. 1996). The KIRC targets were adjusted in average and higher water years to be consistent with VARQ (LMATRIX, ver. 97-06). Curve selection was set to interpolate elevational targets based on the reservoir inflow volume. The critical year function was disabled so that all years were considered critical year 1. The KIRC operation reflects a "smoothed" discharge, modified to reflect inseason management resulting in a more natural discharge shape. The reservoir elevation schedule was then slightly modified to accommodate the new hydrologic balance with the smoothed discharge schedule. Smoothing and reshaping the KIRC was accomplished using Microsoft Excel and multiple iterations using LRMOD.

Biological Modeling

Trophic responses from the two reservoir operations were estimated using the empirically calibrated biological reservoir model LRMOD. Model simulations were set for annual (as opposed to continuous) runs. Thermal effects downstream of Libby Dam were standardized across the alternatives using the automated withdrawal depth specification in the selective withdrawal (thermal control) component. This resulted in identical discharge temperature under both alternatives. Withdrawal depths were based on the existing reservoir surface elevation and thermal profile as calculated by the thermodynamics model component.

For both operation alternatives, we qualitatively assessed fish entrainment through Libby Dam. Entrainment of reservoir fish through Libby Dam turbines can be estimated using the empirically calibrated entrainment model developed for Libby Dam by Skaar et al. (1996) given the necessary field data. Multiple regression analysis explained that most of the raw variance (r^2=0.776) was explained by dam discharge, forebay fish density at 0-10 m above the withdrawal depth and areal fish density for all hydroacoustic transects. Entrainment was correlated with discharge (r^2=0.758). Skaar et al. (1996) found that kokanee constituted over 98 percent of fish entrained at Libby Dam. Since the two operational alternatives presented herein are hypothetical, field data were unavailable. Nonetheless, trends in fish density and vertical distribution can be extrapolated from sampling conducted from December 1990 through June 1993. Potential for entrainment is high in spring and summer when fish congregate near the depth where Libby Dam water withdrawals normally occur (Skaar et al. 1996). Discharges during spring and summer can be accurately estimated through computer modeling. If we assume that the selective withdrawal structure (depth of withdrawal) is consistent in all alternatives, and that seasonal trends in vertical fish distributions are held constant, we can qualitatively assess entrainment under the two alternatives. Differences in discharge volume during the spring and summer period are well correlated with fish entrainment at Libby Dam (Skaar et al. 1996).

RESULTS AND DISCUSSION

Reservoir Conditions

Alternative 1: KIRC/VARQ

Reduced summer drawdown resulting from the KIRC/VARQ operation (Figures 2, 3, and 4) protects aquatic and benthic food production in the reservoirs. Benthic insect life consists almost exclusively of *Dipterans*. Typical lifecycles extend from five weeks to nearly three years. Drawdowns dewater and kill larvae in the reservoir sediments (Marotz et al. 1996). Increased refill frequency improves biological production during the warm months, late May through early September. At full pool, the reservoir contains the maximum volume of optimal temperature water for fish growth and a large surface area for aquatic food production and deposition of terrestrial insects from the surrounding landscape. Refill timing also ensures that species of special concern, including westslope cutthroat trout and bull trout can pass into tributary habitat to spawn and survive. Overall, this operation would allow for roughly 70 percent of the optimum reservoir productivity (Table 2).

Entrainment of fish through Libby Dam is proportional to discharge volume. During spring, fish are concentrated near the surface associated with warmer water as thermal stratification begins to develop; nearly all sonic targets were found in the top 20 m (Skaar et al. 1996). Fish densities in the dam forebay are higher during spring than in any other season. Entrainment would be highest in June when releases are scheduled to mimic the natural spring runoff schedule. As a result of the tiered flow approach, highest entrainment rates would occur in above average water years when spring discharges are high. Lowest entrainment rates would occur in below average water years, proportional to low discharge volumes. Fish entrainment during spring under this alternative would be similar to the NMFS 95 BiOp Alternative 2 in above average water years. Entrainment would be less under this alternative than the NMFS 95 BiOp during average or drier water years. During summer, areal fish densities are lower than in May and June, although densities are typically higher in August than in late fall and winter. Entrainment during August resulting from the KIRC/VARQ alternative would be the less as compared to the NMFS 95 BiOp (Figures 5, 6, and 7).

Alternative 2: NMFS Biological Opinion

Computer simulations performed at BPA Dittmar Control Center show that the NMFS Biological Opinion, in attempting to meet an August flow target of 200 kcfs at McNary Dam, reduces reservoir refill probability (Wright 1996). In some years, the reservoir fails to refill by 20 feet or more. Refill failure reduces biological production in the reservoirs during the productive warm months (Table 2).

Under the NMFS 90 BiOp, a 20 foot draft of Koocanusa will essentially drain the reservoir on the Canadian side of the border so that all that remains in BC is a river flowing through mud flats. The Canadian anglers will not have access to the reservoir and those individuals who have invested in businesses associated with recreation will be greatly impacted. Furthermore, under the NMFS 95 BiOp alternative, fish entrainment through Libby Dam, which is proportional to discharge, would be higher during spring in average and dry water years, and higher during August, compared to the KIRC/VARQ alternative. This draft will entrain kokanee, burbot and the (newly listed) threatened bull trout, out of the reservoir; due to the absence of fish passage facilities these fish cannot get back to the reservoir. In addition to entrainment the draft will affect survival of all fish species since the productive capacity of the Koocanusa Reservoir will de greatly diminished.

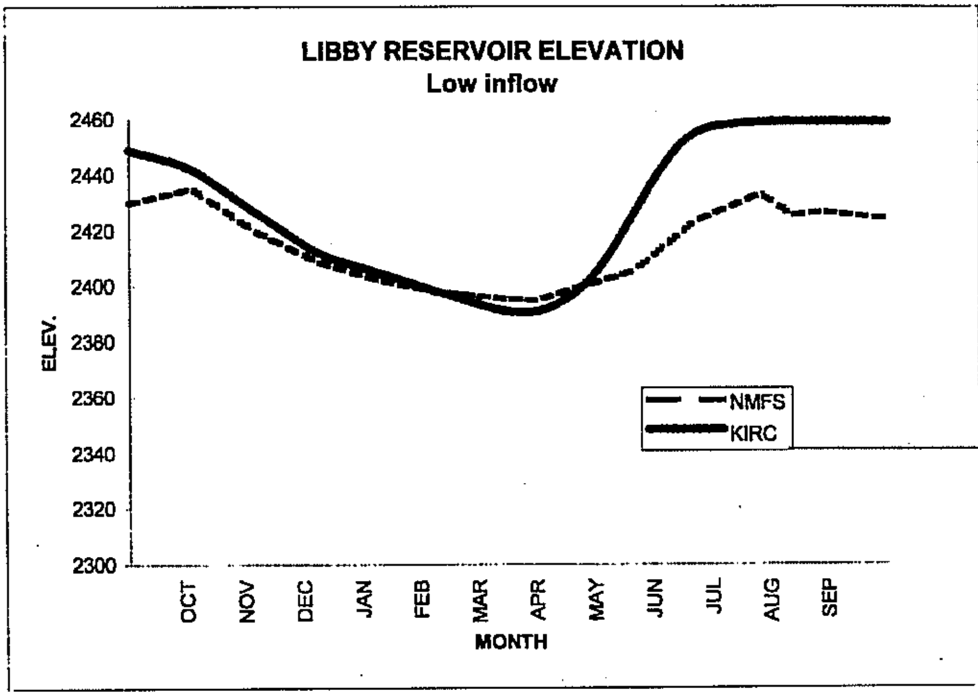


Figure 2. A comparison of Libby Reservoir elevations resulting from the two alternatives under low water conditions.

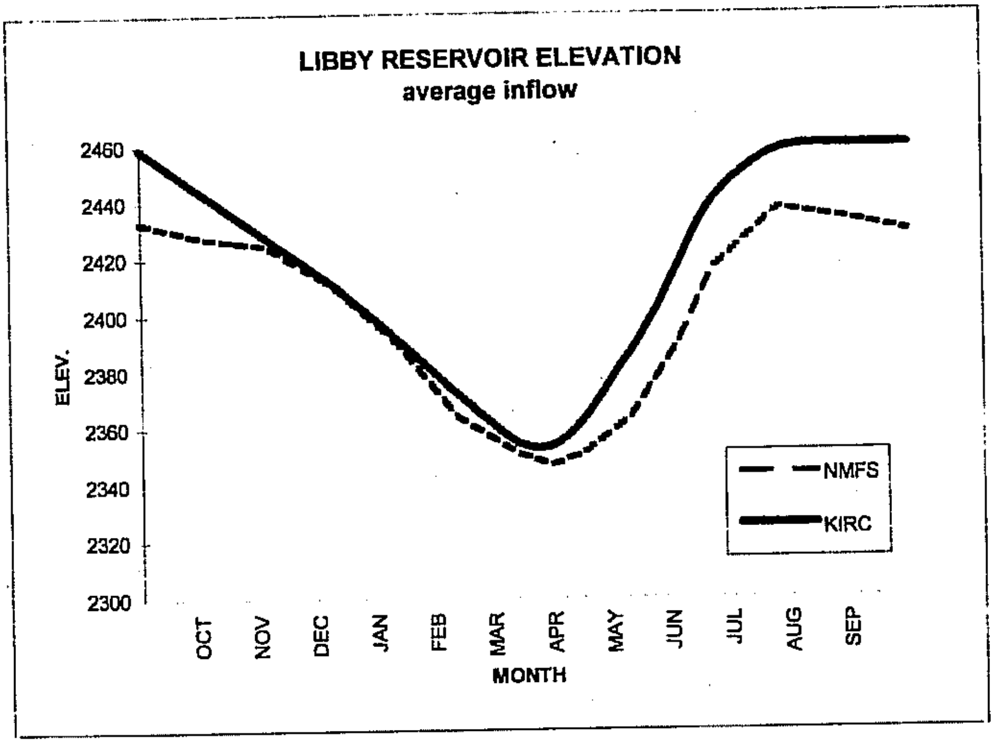


Figure 3. A comparison of Libby Reservoir elevations resulting from the two alternatives under average inflow conditions.

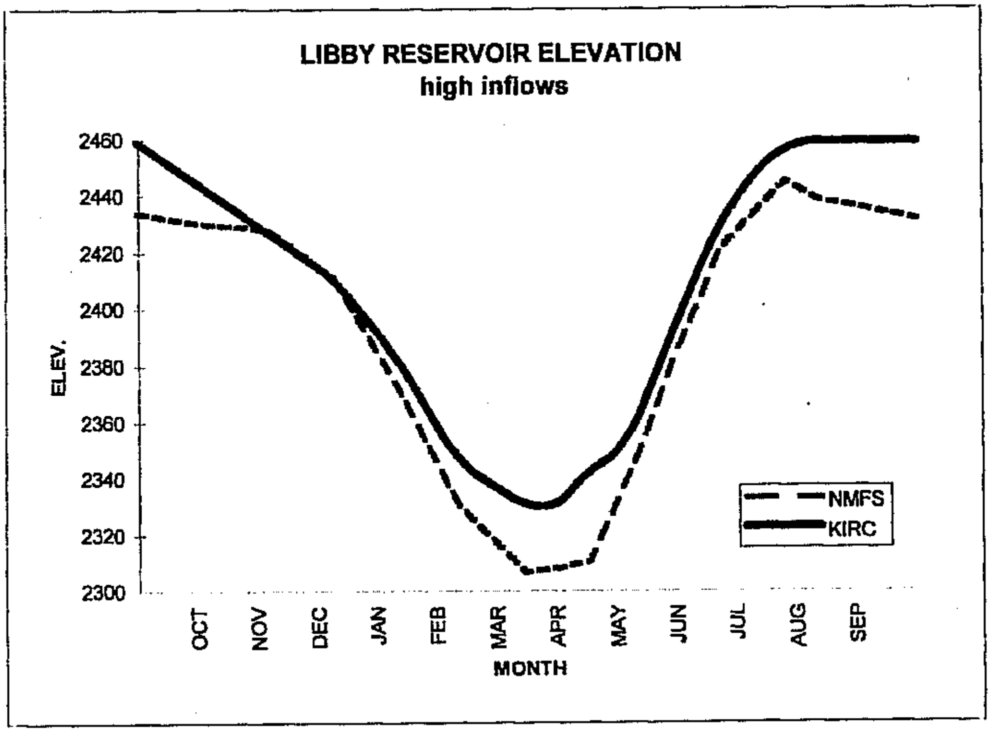


Figure 4. A comparison of Libby Reservoir elevations resulting from the two alternatives under high water conditions.

Table 2. Trophic responses in Libby Reservoir calculated using the reservoir model LRMOD (Marotz et al. 1996).

Alternative		*Primary Production (metric tons)*		*Secondary Production (metric tons)*		*Terrestrial Insect Deposition by Insect Order (% maximum)*				*Fish Growth kokanee*			
										TL (mm)		*Weight (g)*	
Water Avail.	*Name*	*Carbon Fixed*	*Wash out*	*Zoop Prod*	*Bent*[b]	*Col*	*Hem*	*Hom*	*Hym*	*Age I+*	*Age II+*	*Age I+*	*Age II+*
Low	NMFS	11836	37	1354	382.1	74.1	83.3	85.0	85.7	285	386	219	576
	KIRC	13003	30	1489	367.5	79.0	94.7	97.5	99.9	298	412	252	706
Avg.	NMFS	11063	39	1265	337.3	62.0	80.1	83.8	88.7	279	374	205	521
	KIRC	12178	35	1393	303.2	68.8	90.6	94.8	99.9	291	397	233	630
High	NMFS	10820	46	1236	229.7	56.6	80.3	85.0	90.2	278	372	202	510
	KIRC	11680	45	1335	301.5	62.7	87.9	92.9	99.9	287	389	223	589

[a]Results represent phytoplankton production (metric tons of carbon fixed) calibrated by C^{14} liquid scintillation. Phytoplankton washout through the dam (metric tons) calibrated by chlor $\propto$ vertical distribution and entrainment sampling. Total zooplankton production (metric tons) calibrated on phytoplankton production and seasonal measures of carbon transfer efficiencies. Benthic production (metric tons of emergent insects) calibrated on depth distribution of insect larvae and emergence captures. Terrestrial insect deposition (percent of maximum) by insect order Col= coleoptera, Hem= hemiptera , Hom= homoptera, and Hym= hymenoptera, calibrated on near shore (<100 m) and offshore surface insect tows. Fish growth (end of year kokanee size) in total length (TL) and weight (grams) calculated through multi variate analysis on water temperature structure and food availability.

[b]Benthic insect production is artificially enhanced by reservoir refill failure. This single year event is caused when the warm epilimnetic water settles over substrate containing high larval densities (in the infrequently dewatered zone), thus enhancing larval production and emergence. A single deep drawdown event or reservoir refill failure can impact benthic insect production for two years or longer.

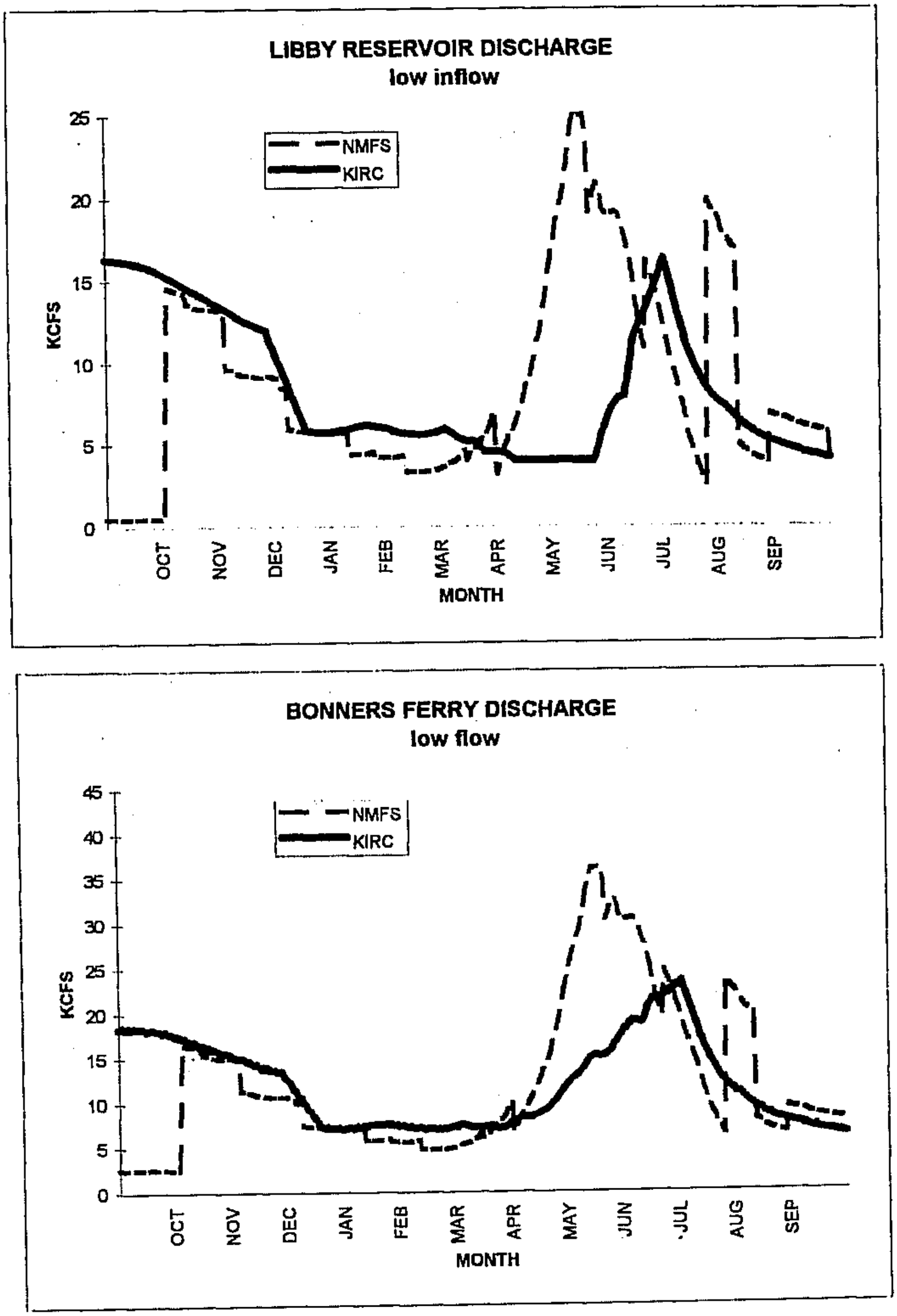
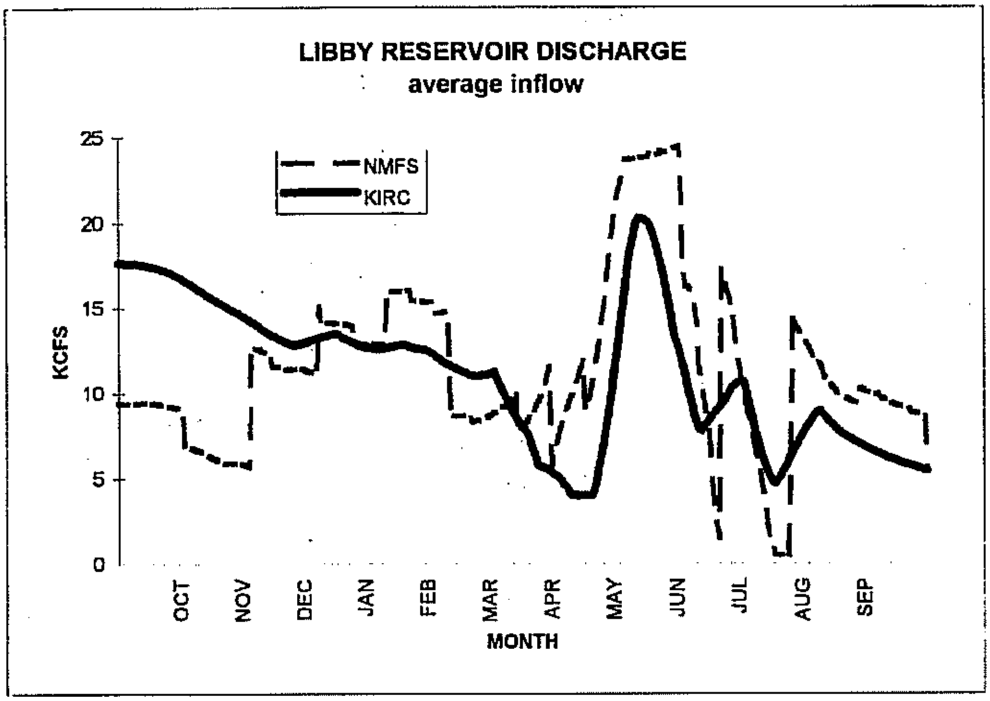


Figure 5. A comparison of Kootenai River discharge resulting from the two alternatives under low water conditions.



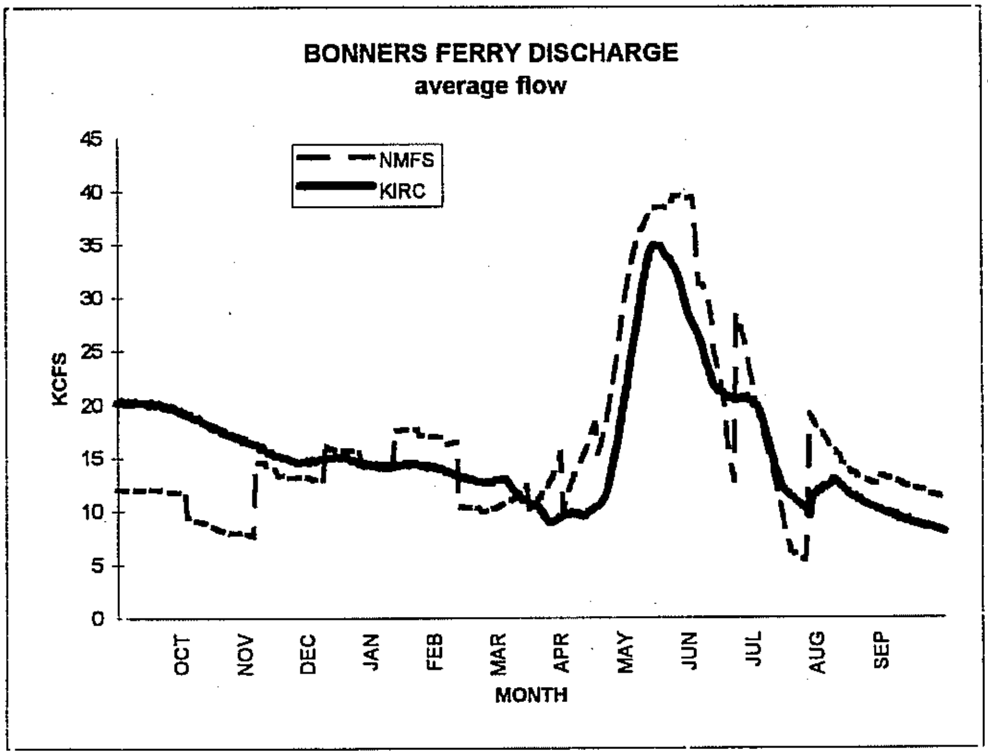
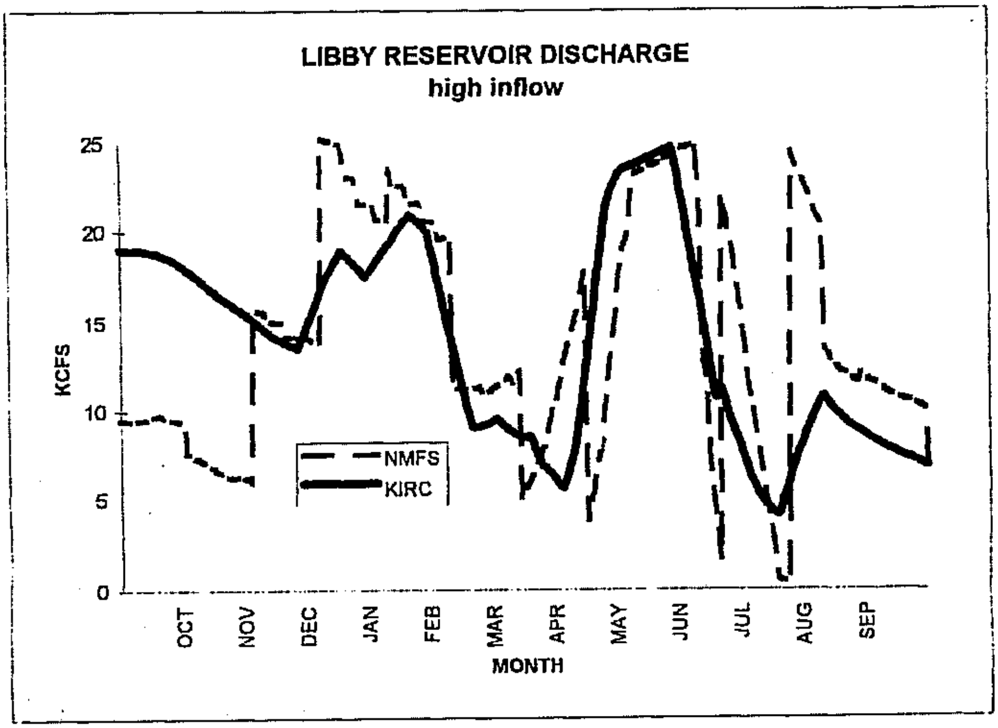


Figure 6. A comparison of Kootenai River discharge resulting from the two alternatives under average water conditions.



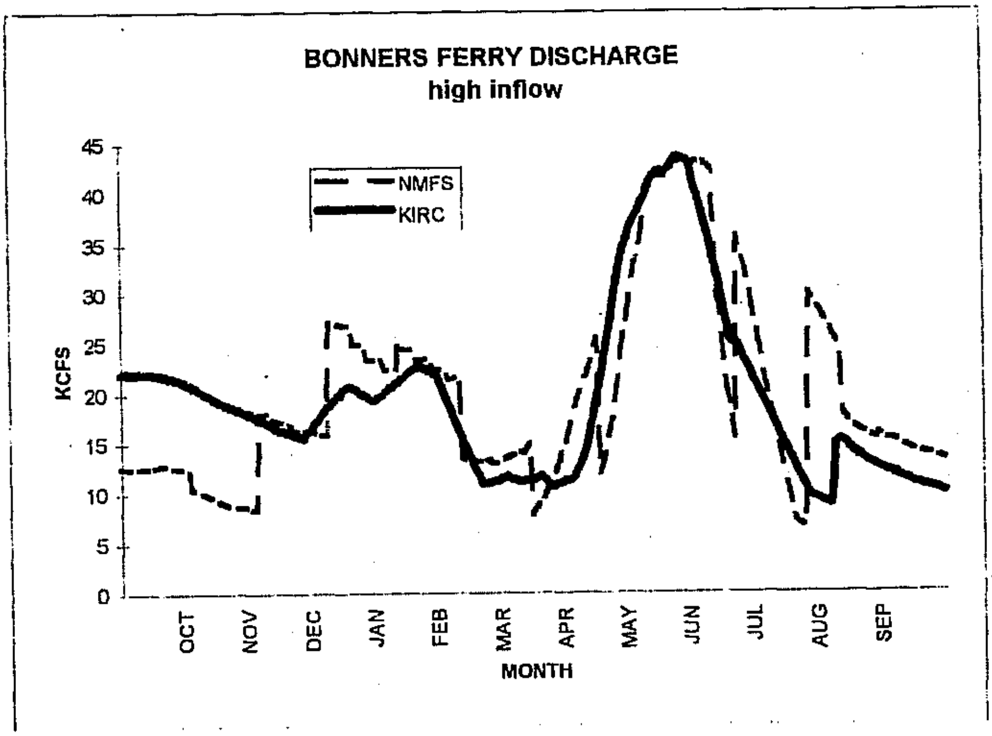


Figure 7. A comparison of Kootenai River discharge resulting from the two alternatives under high water conditions.

Kootenai River Conditions Downstream from Libby Dam

Alternative 1: KIRC/VARQ

An independent comparison of Columbia River flows during spring performed by Wright (1996) revealed that flows resulting from the IRCs (as modeled at Hungry Horse and Libby Dams) were nearly the same as the NMFS Biological Opinion (Table 3). Similarly in this analysis, spring discharges in the Kootenai River, resulting from the KIRC/VARQ operation are nearly consistent with the NMFS Biological Opinion during average to high water years, but less in low water years (Figures 5, 6, and 7). During low water years, the tiered flow approach incorporated into the KIRC/VARQs releases less water than called for by the NMFS Biological Opinion. This is because the tiered flows were designed to balance the effect of flow augmentation on reservoir refill and protect the needs of other fisheries resources in the Kootenai River system, whereas the NMFS 95 BiOp only attempts to meet flow targets in the lower Columbia (NMFS Biological Opinion, reasonable and prudent alternative #1).

The maximum allowable discharge volume at Libby Dam is dictated by the physical capacity of the turbines and acceptable spill levels. Libby Dam presently contains five turbines that can release a maximum of 27 kcfs, collectively. The spillway entrains atmospheric gas during operation, so only a small percentage of the total flow can be spilled before Montana water quality laws pertaining to dissolved gas are violated (e.g. not to exceed 110 percent gas saturation). Thus, the maximum flow in the river downstream of Libby Dam is limited by turbine capacity plus additional flows from unregulated tributaries that enter the Kootenai River downstream from the dam. Flood control criteria at Bonners Ferry, Idaho and Kootenay Lake B.C. (IJC 1938), further limit the maximum allowable flow. The unofficial flood control limit for zero damage at Bonners Ferry is river elevation 1764 feet (Merkle, 1996). Kootenai River surface elevation at Bonners Ferry is affected by river discharge and Kootenay Lake elevation.

The structure of the lotic community is defined by streamflow characteristics (Radar and Ward 1988; Poff and Ward 1989). The naturalized spring freshet resorts and cleans river sediments and restores nutrient cycles and floodplain function. The freshet re-suspends fine streambed sediments and coarser gravels, redefining the stream channel and redistributing bottom materials along the main channel, backwaters and banks (Wesche and Rechard 1980). Coarse cobbles are deposited in areas of high water velocity whereas fine silts and clays settle in calm margins and sheltered areas behind obstructions. Clean, unburied cobble provides interstitial spaces between the stones and ample surface area offering suitable habitat for benthic algae, aquatic insects, and young fish (Perry 1984, 1986; Hauer et al. 1997).

Table 3. Modeling results comparing Columbia River flows at McNary Dam (from Wright 1996).

	Flow in Kcfs April 15-30		
Water Availability	NMFS 95 BiOp	IRC	Difference
Lowest 8 water years	197	177	-20
12 low to medium years	230	221	-7
20 medium to high years	265	268	+3
10 high water years	312	312	0
Average of 50 years	255	251	-4
NMFS 95 BiOp flow target for period 220-260 Kcfs			

	Flow in Kcfs May 1 - June 30		
Water Availability	NMFS 95 BiOp	IRC	Difference
12 low to medium years	186	168	-18
20 medium to high years	238	232	-6
20 medium to high years	305	303	-2
10 high water years	386	383	-3
Average of 50 years	286	280	-6
NMFS 95 BiOp target flow for period 220-260 Kcfs			

'In this study the VARQ flood control strategy was not modeled. The IRC targets were superseded by existing "status quo" flood control curves if the flood control elevation was lower than the IRC. This resulted in lower spring flows during medium to dry years than would occur following KIRC/VARQ.

Gravels are deposited along the main channel where water velocity is reduced. Clean gravels with subsurface water seepage and groundwater inflow are sought by nest-building salmonids and broadcast spawners (Weaver and Fraley 1993; Peters 1962). Salmonid redds, constructed in gravels consisting of less than 30 percent fines (<0.65 cm) provide suitable oxygenation for incubating salmonid eggs and sack fry, enhancing survival through hatch and emergence (Weaver and Fraley 1993). Gravelly riffles are important for insect production and provide security habitat for fry and fingerlings. Preferred spawning substrate for white sturgeon, which are broadcast spawners, consists of gravel, cobbles and boulders (Hildebrand and McKenzie 1994; Parsley et al. 1993). Monitoring in the Kootenai River since 1991 indicates that most sturgeon egg deposition occurs over gravel and sand. This may be a result of inadequate river flows or Kootenay Lake elevations to attract sturgeon to areas with larger substrate materials (e.g. upstream of Bonners Ferry). In 1997, Kootenay Lake surface elevation and inflows remained high and several mature radio tagged sturgeon were documented upstream from Bonners Ferry, ID (Vaughan Paragamian, personal communication).

Fine clays, silts, sands, and organic materials deposited in low velocity areas (e.g. high on the streambanks) become dry as spring flows gradually recede. If stream flows stabilize at basal conditions, this rich soil becomes tightly bound by the roots of terrestrial vegetation. As plants recolonize the dewatered substrate, erosion and subsequent siltation of the streambed are reduced. Fine materials remaining in the stream support emergent vegetation and vascular aquatic plants. Established vegetation provides habitat for aquatic and terrestrial organisms. The KIRCs gradually ramp down from the spring runoff peak and moderate flow fluctuations, thus restoring these favorable biological conditions.

Under the more natural annual flow pattern provided by the KIRCs, the nutrient cycle more closely resembles pre-dam conditions compared to the NMFS 95 BiOp. Nutrients are carried with clay particles and organic materials during the freshet, similar to an unregulated system. Free nutrients released into the water fertilize primary producers at the base of the aquatic food web. Biological production increases with rising water temperatures as the summer progresses and flows decline to basal low flow conditions. Secondary production (e.g. zooplankton, insects, and mollusks) determines the amount of food available for tertiary consumers (including white sturgeon, other listed salmonids, and their prey).

Alternative 2: NMFS Biological Opinion

The NMFS Biological Opinion creates an augmented spring freshet followed by a trough, then a second flow peak in August (Figures 5, 6 and 7). The second peak in August is a departure from the natural hydrograph which would decline from a June peak to basal low flows by late July. A rapid flow reduction between the peaks would dewater a large portion of the river margins, stranding insects, zooplankton, fish and fish eggs (Hauer 1987; Armitage 1984; Hauer and Stanford 1982). The unnatural pulse of water during the biologically productive summer months is not consistent with the normative river concept described by the Independent Scientific Group (ISG 1996).

Prior to dam construction, summer flows in the Kootenai River gradually fell from approximately 11,000 cfs to 8,000 cfs during the month of August (Libby Dam Water Control Manual Plates 9-2, 3 & 4). However, the twenty foot August draft, called for by the NMFS 95 BiOp, would augment the flow with an additional 14,450 cfs from reservoir storage (resulting in a sudden increase in the hydrograph that would taper from 25,450 cfs to 22,450 cfs during the month of August) increasing the flow as much as 600 percent of the natural basal flow condition. The following effects would result.

A large expanse of the riverbed is flooded, then dewatered twice during the crucial larval sturgeon development period. This zone of fluctuation or "varial zone" is enlarged by unnatural flow fluctuation (Hauer et al. 1997). Aquatic organisms that colonize the varial zone may be unable to return to the river as the water recedes, becoming stranded on the dry banks (Perry 1984, Hauer et al. 1997.). Aquatic insect production that requires nearshore habitat stability is reduced or lost. The varial zone becomes biologically unproductive, diminishing overall system health. Fluctuating or abnormally high discharges also disrupt the natural revegetation, insect, and larval fish recolonization process. Aquatic and terrestrial vegetation that would normally provide secure habitat along the river margins and stabilize soils can not fully reestablish and fine materials are more easily eroded and swept back into the channel.

Hyporheic interactions, or groundwater interchange with the surface flow, can also be altered by intermittent, abnormally high flows. Augmented summer flows may increase the river stage by up to 4 feet. This amount of head differential can effect the direction of water flow into or out of groundwater storage in shallow unconfined aquifers which could also have negative effects on biological production. Fluctuating flows and resulting river stage changes alternately saturate and dewater the streambanks. Sediments carried with return flows can undercut and weaken the river banks, causing bank failure and increased sedimentation. Groundwater inflow can fertilize the river channel (Stanford and Hauer 1992) affecting eutrophication with positive or negative consequences. Thermal refuge for aquatic biota created by groundwater recharge can be influenced by hyporheic flow. Intermittent, frequent flow fluctuations also compromise the success of sturgeon experimental flows and higher velocities and river stage reduce the effectiveness of certain types of sampling gear when mature eggs and larval sturgeon are expected to be present in the Kootenai River.

Kootenay Lake Conditions (British Columbia)

Releases from Libby Dam effect water retention time, and thus biological productivity in Kootenay Lake, British Columbia. The warm, sunlit epilimnion contains the highest density of photosynthetic phytoplankton, as well as zooplankton. As inflow to the lake increases, more water must flow through the outlet or be stored in the pool. If the pool elevation is stable or declining, inflowing waters displace a commensurate volume that passes through the outlet. The physical configuration of Kootenay Lake, including a shallow sill at the outlet to the West Arm and a downstream control called Grohman Narrows at the outlet to Corra Linn Dam, result in an epilimnetic release of water from the lake. Decreased water retention in the lake's epilimnion results in greater downstream loss (entrainment) of organisms through the turbines. This effect, caused by high summer discharges from Libby Dam is exacerbated during the summer when thermal stratification in Kootenay Lake is well established. Downstream loss of free nutrients and biomass reduces food availability within the lake which is home to white sturgeon. Concerns over nutrient levels in the lake are evident by past investigations of nutrient loading (Daley et al. 1981) and ongoing lake fertilization experiments being conducted by Ashley and Thompson (1996).

Alternative 1: KIRC/VARQ

Dam releases under this alternative were designed to create a gradual ramp down from the spring runoff toward basal flows. Water retention time in the epilimnion of Kootenay Lake would therefore be greater than Alternative 2 during the warm summer months because Libby Dam discharge is least.

Alternative 2: NMFS Biological Opinion

The late summer water releases from Libby Dam called for by the NMFS Biological Opinion would cause the highest rate of water exchange in Kootenay Lake's epilimnion. Downstream loss of the most productive surface layer of Kootenay Lake would reduce food availability for lake-dwelling species. The Province of British Columbia has been fertilizing the North Arm of Kootenay Lake for the past seven years. The kokanee that the Ministry of Environment is attempting to recover spend a considerable portion of their lives in the South Arm. The large block of water that will have to pass through the South Arm in August will result in a net export of fish and their food, primarily cladocerans. This will likely affect survival of these kokanee and may jeopardize the overall success of the fertilization program which costs in the order of $400 to 500K per year.

Downstream from Kootenay Lake, the Kootenay River passes through numerous small (and old) hydro dams. This water must be passed relatively quickly and will likely result in increased levels of dissolved gas supersaturation as these projects are not capable of dealing with large volumes of water. In addition, BC Hydro may lose considerable power benefits by passing this water at a low-demand time of year.

Burbot, white sturgeon, and kokanee are in jeopardy in the Kootenay River downstream from the Canada-USA border. A large block of water in August, an unnatural event, will affect the survival of these fish by reducing productivity, eliminating certain habitats, moving fish downstream and possibly killing certain fish either directly, e.g., juvenile sturgeon, or indirectly, e.g. relocating some species such as burbot to habitats where they would be exposed to predators.

The Columbia River downstream from the Kootenay River confluence contains threatened stocks of sturgeon and burbot that would be further impacted by high levels of gas supersaturation as well as high flows at an unusual time of year. BC Hydro, Department of Fisheries and Oceans (DFO) and the Ministry are expending substantial resources trying to maintain this ecosystem for the aforenamed species as well as other sport fish, e.g., rainbow trout, mountain whitefish. Furthermore, other threatened and endangered species in this stretch of river, as well as various cottids and cyprinids would be affected by a high summer flow.

Effects on White Sturgeon

Although mature white sturgeon eggs have been captured in monitoring studies in recent years since Libby Dam began operating, only one larval and three pre-hatch sturgeon have been collected to date (Paragamian et al. *In Press*). Yearling sturgeon released experimentally from a conservation aquaculture program have survived to be recaptured in subsequent years. Sub-yearling survival is critical to natural recruitment and recovery of the endangered Kootenai River white sturgeon population. Although river discharge is but one of several environmental mechanisms suspected to influence early life survival, flow regulation effects all riverine trophic levels (Richards 1997, Poff and Ward 1989).

Reestablishment of a more substantial spring freshet (as constrained by flood control criteria) will re-sort some of the river substrate, creating more suitable spawning substrates, which benefits invertebrate production and food availability for tertiary
consumers (fish). A bank full flow should occur on a frequency of once every 2.5 years to maintain channel integrity (Wesche and Rechard 1980). Predation on the eggs of broadcast spawning fish species (e.g. white sturgeon) is reduced when eggs settle into interstitial space provided by cobble and coarse gravel substrates (Parsley et al. 1993), likely enhancing early life survival.

Alternative 1: KIRC/VARQ

Spring flows necessary for river channel maintenance and to re-sort and clean river substrate are presently limited by the physical structure of Libby Dam and flood control requirements. Libby Dam discharge is presently limited to maximum turbine capacity in five units (approximately 27,000 cfs). Flows from unregulated tributaries between Libby Dam and Kootenay Lake supplement dam discharge downstream. Maximum flows are regulated by maximum allowable flood stage (approximately 60,000 cfs) at Bonners Ferry which eliminates the extremely high flows necessary to completely resort the river substrate. Flow regulation has resulted in substrate imbeddedness and the buildup of deltaic materials at the mouths of tributary streams.

The tiered flow approach in the KIRC/VARQ alternative reestablishes a more natural spring runoff period. Model simulations estimate that combined flows in excess of 50,000 cfs can be achieved at Bonners Ferry in approximately four out of every ten years (Marotz et al. 1996). Approximating the bankfull flow on this frequency is expected to reduce imbeddedness and clean interstitial spaces in riffle areas. Flows during dry years are less under the tiered flow approach than those specified by the NMFS 95 BiOp.
The timing of spring flow augmentation would mimic pre-dam conditions, as dictated by the tiered flow approach. The frequency and volume of bankfull flows are controlled by turbine capacity and flood constraints as in the other alternatives. The gradual ramp down from the spring peak mimics the descending limb of the pre-dam hydrograph that was typical. Historically, white sturgeon incubation, hatching and early fry stage coincided with gradually declining flows, immediately after the spring runoff.

Flows resulting from the gradual ramp down from the spring peak may reduce predation mortality in larval sturgeon by increasing the area of submerged riverbed, thus increasing security habitat. This potential was supported by a risk-ratio calculation of instantaneous mortality (Carl Walters, University British Columbia, personal communication, Kootenai River Modeling Workshop February 18, 1997). A sudden decrease in white sturgeon recruitment occurred in 1973 and 1974 when Libby Dam began impounding the Kootenai River. Flows reduced by approximately a factor of 10 during the period when sturgeon eggs are incubating and fry are emerging (late May through early July). The decreased volume of water would accordingly concentrate predators and prey in a smaller area, increasing the risk of predation mortality. Thus, a gradual ramp down from the spring peak should reduce predation on white sturgeon fry. More stable flows during the biologically productive spring and summer months would benefit biological production in the affected river reach.

Alternative 2: NMFS Biological Opinion

The spring release called for by the NMFS 1995 Biological Opinion is similar to Alternatives 1 in that it would mimic the natural spring runoff. Maximum flows are regulated by maximum turbine capacity and allowable flood stage. Bankfull flows could be achieved on the same frequency as the KIRC/VARQ.

However, the August release is inconsistent with the restorative flows recommended in KIRCs in the Kootenai River. White sturgeon can be directly affected (through stranding of juveniles) or indirectly affected (through food web dynamics) by summertime flow augmentation (Stanford et al. 1996, Hauer et al. 1997). A large expanse of the riverbed is flooded, then dewatered twice during the period crucial to sub-yearling sturgeon development and survival. Summer releases dictated by the NMFS Biological Opinion, therefore, likely impact post-larval survival and may hamper recovery of the endangered Kootenai River white sturgeon population.

Although information on early life habitat requirements of sub-yearling Kootenai white sturgeon is incomplete, the Team is concerned that rapid flow reduction following the sturgeon release could strand larvae or juveniles if they utilize the river margins or backwater areas. Unseasonably high water velocities during August could displace juvenile sturgeon that evolved under a natural hydrograph that provided more stable low flows during the critical life cycle stage from fry to yearling.

Flow fluctuation during the most productive warm months could also negatively affect sub-yearling sturgeon feeding and food resources. White sturgeon food habits during their first year include insects and other invertebrates known to be impacted by flow fluctuation (Hauer et al. 1997). Scott and Crossman (1973) reported that age 0 white sturgeon diets consisted predominantly of Chironomid larvae. The amphipod Corophium accounted for 98 percent of diet items from 149 age 0 white sturgeon (20-267 mm TL) collected from Bonneville and The Dalles pools in the Columbia River from (Sprague et al. 1993). Wydowski and Whitney (1979) reported that the stomachs of small white sturgeon in California contained primarily *Mysis* shrimp and amphipods. Age 0 lake sturgeon (*Acipenser fulvescens*) were observed in close contact with the substrate, oriented upstream, apparently feeding on drifting benthic organisms (Kempinger, 1996). Kempinger (1996) also reported that species of Baetidae nymphs and Dipteran larvae were the two principle organisms consumed by lake sturgeons during their first summer of life. Paragamian et al. (1997) found that chironomid larvae make up over 90 percent of the stomach contents of 23 juvenile white sturgeon recaptures of hatchery fish stocked 2-3 months earlier in the Kootenai River. Obviously, any flow operation that reduces invertebrate production and abundance could have a negative effect on sub-yearling white sturgeon growth and survival.

Other Effects

A new strategy for system flood control (VARQ) is required to balance the needs of reservoir and anadromous in the Columbia system. VARQ was critically examined by technical modelers of the Army Corps of Engineers (ACOE) Hydraulics and Hydrology Branch. ACOE modelers established that the KIRCs were nearly identical to a new system flood control strategy being developed by the ACOE in average to high water years. Earlier problems identified by ACOE modelers (e.g. April releases and insufficient drawdown in the highest ten percent of water years) have been corrected so that the KIRCs are now consistent with VARQ in high water years. Differences between VARQ and KIRCs during lower water years are a result of integrating power constraints. This variable flow strategy (VARQ) is crucial to increasing and shaping spring runoff (within flood constraints) while maximizing reservoir refill probability. A preliminary flood control analysis on VARQ and KIRCs was completed by ACOE in February of 1997. A combination of KIRCs and VARQ is being explored for Libby operation based on that information, which indicates that flood control requirements can be met for Bonners Ferry providing that adequate drafting occurs in high-runoff years.

Wright (1996) reported that the enhanced reservoir operation (IRC concept) was the least expensive of the alternatives analyzed, saving the power system an annual incremental average of $27 million as compared to the NMFS Biological Opinion. Furthermore, the mathematical decision process for establishing reservoir elevations and flow targets, based on updated inflow forecasts, is amenable to power and flood control planning.

In the past, BC Hydro has tried to accommodate the NMFS demand for a 20 foot draft of Koocanusa by implementing what is termed the Arrow-Libby swap. The problem with this operational practice is that the kokanee populations in the Arrow Reservoir have collapsed, primarily due to a lack of productivity. Just as with Kootenay Lake, a drawdown of the Arrow to provide water for the NMFS flow target at McNary will affect kokanee survival in the Arrow by flushing some of the remaining kokanee and their food out of the reservoir.

CONCLUSIONS

Water released for salmon during dry years as called for in the NMFS 95 BiOp would disrupt the desired balance between Kootenai River white sturgeon recovery needs, resident fish needs, and Libby Reservoir refill probability which effects biological productivity in the reservoir and river. Reservoir refill failures during dry years are expected under the KIRC/VARQ operation, but less frequently than would occur by implementing the NMFS Biological Opinion. Extreme reservoir refill failure (more than 20 feet) negatively affects biological production in the reservoir, entrains more fish through Libby Dam, and negatively affects fishing, recreation, and tourism. Reservoir refill failure in the U.S. and Canadian portion of the Kootenai system compromises the system's ability to store water for release during the following spring. The best conditions for white sturgeon and the Kootenai River ecosystem can be achieved by implementing operations similar to the KIRC/VARQ at Libby Reservoir and other Columbia Basin storage projects (e.g. Mica, Arrow, Dworshak). In doing so, sub-basins experiencing wet conditions can supply the bulk of salmon flow augmentation, while dry sub-basins would provide less flow, protecting important reservoir and riverine stocks. Combined flows from the headwater sub-basins could then be shaped to achieve the greatest benefit for salmon and other anadromous stocks while protecting fish populations in the dry sub-basins. A gradual ramp down from the spring runoff in the sub-basins can be used to normalize the river hydrograph below headwater projects.

We agree with NMFS that ESA recovery actions throughout the entire Columbia River Basin should be balanced and coordinated to accomplish simultaneous recovery of multiple species throughout the Columbia Basin. Given the available information, the Team believes the KIRC/tiered flow operation best meets this objective (Table 4). The KIRC tiered flow approach uses available water to mimic natural hydraulic conditions, provides an experimental design to assess environmental conditions need for natural recruitment of juvenile white sturgeon to the Kootenai River population, and balances recovery actions while providing adequate habitat conditions for the threatened bull trout and other non-listed fish stocks consistent with ESA. Pass through flows can be shaped to achieve the greatest benefit for sturgeon, salmon, bull trout, and non-listed stocks. Finally, implementation of the KIRC tiered flow approach will require that research and monitoring efforts focus on the benefits and impacts of summer flow augmentation so that areas of conflict can be resolved based on empirical scientific evidence.

Table 4. A descriptive comparison of the two operational alternatives. Symbols denote biological responses to the various operational strategies (see footnote[2]).

Physical or Biological Effect	Alternative 1 KIRC/VARQ	Alternative 2 NMFS 95 BiOp
Reservoir Refill Probability	✩	☆
Maximum Reservoir Drawdown	★	✬
Primary Productivity	✩	✬
Zooplankton Production	✩	✬
Benthic Insect Production	★	✩
Terrestrial Insect Deposition	✩	☆
Fish Growth	★	☆
Fish Entrainment Loss via Turbines	★	☆
Flow Fluctuation (size of varial zone)	★	☆
Riverine Biological Productivity	✩	☆
Impacts to White Sturgeon	✩	☆
Kootenay Lake Water Exchange Rate - Epilimnion	✩	☆
Salmon Spring Flow Augmentation Low Inflow	✬	★

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[2] Symbols are ordered from biologically optimized ★, productive ✩, low productivity ✬, and poor condition ☆.

Physical or Biological Effect	Alternative 1 KIRC/VARQ	Alternative 2 NMFS 95 BiOp
Salmon Spring Flow Augmentation Average Inflow	✫	★
Salmon Spring Flow Augmentation High Inflow	★	★
Salmon Summer Flow Augmentation Low Inflow	☆	✬
Salmon Summer Flow Augmentation Average Inflow	✬	✫
Salmon Summer Flow Augmentation High Inflow	✫	★

[1] Symbols are ordered from biologically optimized ★, productive ✫, low productivity ✬, and poor condition ☆.

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APPENDIX C. Kootenai Basin Integrated Rule Curves and Tiered Approach for White Sturgeon Flow Release from Libby Reservoir.

The Model

A FORTRAN simulation model was developed by Montana Fish, Wildlife & Parks and Montana State University for Libby Reservoir (also known as Koocanusa Reservoir) located in northwestern Montana (Marotz et al. 1996). The model simulates the physical operation of the dam, including experimental flow augmentation for white sturgeon recovery and downstream flood concerns, and predicts the resulting thermal structure of the reservoir and tailwater temperature. Biological responses include: primary production in the reservoir and washout through the dam turbines, zooplankton production and washout, the deposition of terrestrial insects on the reservoir surface, benthic dipteran production and body growth of the major game fish, kokanee. Input to the model is restricted to annual inflow forecasts, the annual inflow hydrograph, minimum and maximum outflow limits, and a proposal of either the annual surface elevation schedule or the annual schedule of dam discharges. The model user has the option to specify the depth at which water is withdrawn from the reservoir throughout the simulation to control water temperature in the discharge, or the model will automate depth selection to meet a pre-programmed temperature regime downstream. All other parameters and coefficients were fixed based on a long-term source of empirical data (1983-1996). Additional data were used to refine the model during the ensuing years. The model was designed to generate accurate, short-term predictions specific to Libby Reservoir and is not directly applicable to other waters. The modeling strategy, however, is portable to other reservoir systems where sufficient data are available.

The model was empirically calibrated using field data from an extensive sampling program 1983 through 1990 (Chisholm et al. 1989; Fraley et al. 1989, and MFWP file data). Field data from 1991 through 1997 were used to expand the utility and correct uncertainties in the model. The physical model facilitates the assessment of power and flood control operations under varying water conditions, drought to flood. Biological components were designed to compare one operational strategy to another, and assess their relative effects on the aquatic environment. The model simulates the water balance in the Kootenai River, Kootenay Lake, Duncan Dam and Corra Linn Dam operations.

Reservoir operation guidelines were developed to balance fisheries concerns in the headwaters with anadromous species recovery actions in the lower Columbia River. Fisheries operations were integrated with power production and flood control to reduce the economic impact of fisheries recovery actions. An earlier version of the operating plan (called Integrated Rule Curves or IRCs) were critically reviewed in the Columbia Basin System Operation Review (SOR EIS 1995; Geist et al. 1996), a process funded by the National Marine Fisheries

Service and BPA to balance salmon recovery with resident fish concerns (Wright 1996), the Fisheries Research Institute (Dr. James Anderson and Dr. Gordon Swartzman), and were determined to be consistent with the Normative River concept (ISG 1996). The IRCs were adopted by the Northwest Power Planning Council during their phase IV amendment process (NPPC 1994) and could have been implemented beginning in 1995. The original IRCs were subsequently modified by the White Sturgeon Recovery Team to refine relationships specific to white sturgeon and to better balance the requirements of resident and anadromous species. A variable release schedule was programmed to assess experimental recovery actions for the endangered Kootenai River white sturgeon. The resulting operational plan was named the Kootenai Basin Integrated Rule Curves (KIRCs).

The KIRCs are a family of operational rules for dam operation that incorporate incremental adjustments to allow for uncertainties in water availability. Dam operation is scheduled based on inflow forecasts and the physical character of the drainage basin and dam design. The first inflow forecast of the year becomes available in early January. Upon receipt of the forecast, the dam operator would store or release water to achieve the correct elevation as described by the curve corresponding with that inflow forecast. Upon receipt of an updated forecast, the operator would adjust the elevation to the new curve corresponding with the updated inflow volume and so on. This causes the actual operation to be flexible and variable over time. Actual operations will vary somewhat from the target elevations due to inflow forecasting error. The curves were designed to limit the duration and frequencies of deep drawdowns and reservoir refill failure and produce a more natural discharge hydrograph. Reduced drawdown protects aquatic food production in the reservoirs, assuring an ample springtime food supply for fish. Increased refill frequency improves biological production during the warm months. At full pool, the reservoir contains the maximum volume of optimal temperature water for fish growth and a large surface area for the deposition of terrestrial insects from the surrounding landscape. Refill timing also assures that passage into spawning and rearing habitats in tributaries is maintained for species of special concern in Montana, including westslope cutthroat trout and the bull trout. Biological production in the free flowing river reaches downstream is protected by the more naturally shaped hydrograph. The naturalized spring freshet resorts and cleans river sediments and helps restore nutrient cycles and floodplain function. The volume and shape of the spring freshet is based on water availability. Flows released from Libby Dam then continue downstream to aid anadromous salmon smolt migration.

Results

Problems occur for resident fish in reservoirs when the pool fails to refill or is drawn down beginning in late summer or early fall. The reduced volume and surface area limits the fall food supply and volume of optimal water temperatures during the critical trout growth period. The food web supporting fish is most productive in the shallower and warmer littoral or nearshore zones of the reservoirs during the summer months. The contribution of terrestrial insects as a food source for fish is reduced as the surface area shrinks and water recedes from shoreline vegetation with a drawdown. These insects are most abundant near the shore from June through September and are the most important food supply for insectivorous fish species during summer and fall. Surface elevations continue to decline during winter, arriving at the lowest point in the annual cycle in April. Aquatic insects are killed as water recedes from the littoral zone. Benthic insects are an important spring food supply for westslope cutthroat trout, a species of special concern in Montana, and other important game and forage species. Frequent dewatering reduces the biomass of insects, especially because the shallow zone is the most productive for insects. At least two years are required for aquatic insect populations to rebound after a single deep drawdown event. Deep drawdowns also increase the probability that the reservoir will fail to refill during the following year. Zooplankton, an important food for kokanee, juvenile trout and adult trout during winter, are washed out of the reservoir through dam turbines as the reservoir shrinks. Thus excessive reservoir drawdown and refill failure impact fish food availability and, therefore, fish growth, and recreation (Chisholm et al. 1989; May et al. 1988; Marotz et al 1996). Modeling and field research indicate that reservoir productivity can, with time, rebound after infrequent deep drawdowns. However, even infrequent drawdowns have lasting biological effects.

KIRCs limit the duration and frequency of deep drawdowns and reservoir refill failure. Reduced drawdown protects aquatic insect larvae, assuring that a large percentage will survive to emerge as pupae and adults. Increased refill frequency improves biological productivity during the summer months, provides an ample volume of optimal temperature for fish growth, and a large surface area for deposition of terrestrial insects during the summer months. Refill also assures that passage into spawning tributaries is maintained for adfluvial trout, including westslope cutthroat and bull trout.

Outflows from the dams affect the river ecology. River flows are crucial to all life stages of aquatic organisms. Spring flushing flows sort river gravel and define the channels creating a healthy environment for fish and the food organism that they depend on. Flow fluctuations during the rest of the year, especially the productive summer months, are harmful to aquatic life. The resulting zone of fluctuation, or varial zone, becomes biologically unproductive habitat, diminishing system health. Aquatic insects, fish and fish eggs occupying the varial zone may be unable to return to the river as the water recedes, becoming stranded on the dry banks. Fluctuating or abnormally high discharges also disrupt the natural revegetation process. Aquatic and terrestrial vegetation that would normally provide secure habitat along the river margins and stabilize soils cannot fully reestablish, and fine sediment materials are more easily eroded and swept back into the channel. In a natural river environment, the nearshore habitat is productive and critical to fish. Riparian vegetation reestablishes seasonally, providing secure habitat along river margins and reducing erosion of silt into the river. If flow fluctuation is reduced by gradually ramping down discharges (as in the KIRCs), impacts to biological production can be reduced.

Local and System Flood Control

Kootenai River flood control measures extend downstream to Corra Linn Dam at the outlet from Kootenay Lake. The model calculates side flows to the Kootenai River (from inflowing water sources) between Libby Dam and Bonners Ferry, Idaho, and sources flowing into Kootenay Lake, British Columbia. Kootenai River flow targets are calculated at Bonners Ferry, and elevational targets at Kootenay Lake, to avoid flooding. Dynamic estimates of side flows can also be added to Libby Dam discharges to calculate the resultant flow at Bonners Ferry. Inflows to Kootenay Lake, flood storage at Duncan Reservoir and lake/discharge relationships for Corra Linn Dam were incorporated into the model to mimic coordinated flood control measures stated in the International Joint Commission Treaty.

The KIRC strategy for flood abatement is to route water through the system so that large peaks in runoff are eliminated, similar to the Variable Flow (VARQ) flood control strategy developed by the Army Corps of Engineers (ACOE). The ACOE Hydraulics Branch critically compared the original IRCs and VARQ and determined that the strategies were similar, with notable differences. In less than average water years, VARQ required less drafting for flood control than the currently used ACOE flood control rule curves, and reservoir elevations were higher than those described by the IRC's. We view this as an opportunity for more operational flexibility above the IRCs so that more water can be "saved" during dry years to augment spring flows and to create a naturalized spring freshet (within flood constraints) without compromising reservoir refill. In average to medium high water years, VARQ and IRCs were identical. This is an improvement over historic operations because reservoir elevations remain higher prior to the spring runoff, so that a larger percentage of the runoff volume can be shaped to create a normalized spring freshet while improving reservoir refill probability. The ACOE analysis revealed that during high water years at Libby Dam, the VARQ required slightly lower elevations for flood control than the IRCs. In response, during 1996 the FWP and the Confederated Salish and Kootenai Tribes (CSKT) adjusted the Libby KIRCs downward to be consistent with VARQ. In doing so, we reduced the risk of a forced spill due to reservoir overflow and associated gas supersaturation in the river downstream. This variable flow strategy (VARQ) is crucial to create a naturalized spring runoff (within flood constraints) while maintaining reservoir refill probability. Careful implementation of IRC/VARQ at Libby Dam will improve spring flows for Kootenai white sturgeon and anadromous stocks in the lower Columbia, while simultaneously improving conditions for westslope cutthroat and bull trout.

Tiered Approach for Kootenai White Sturgeon Spawning Flows

Based on currently available information, white sturgeon in the Kootenai River require a naturalized spring freshet and favorable water temperatures to promote recruitment of juveniles. Spawning has been documented at spring flows of only 20 kcfs, but survival from eggs to yearling stage appears to be related to flow and temperature. We have therefore developed an experimental flow augmentation plan that is based on water availability (reservoir inflow forecasts). The volume of the planned releases are larger in high water years and smaller in low water years.

This Tiered Flow Approach relies on the Army Corp's VARQ flood control strategy, which differs from the flood control operation currently being implemented by the Army Corps. The existing operation attempts to store as much of the spring runoff as possible. This requires a large reservoir drawdown to evacuate sufficient storage to contain the spring runoff, and dam discharge during the spring runoff is held to the minimum allowable flow. Conversely, the VARQ/Tiered flows embodied in the KIRCs plans to release a naturally shaped spring freshet during runoff and stores only the amount of water that would exceed flood capacity in the river downstream. By doing so, less reservoir drafting is required, which benefits reservoir biology. It also improves reservoir refill because less water is required to refill the smaller volume of vacated storage capacity. VARQ enables dam operators to store more water prior to runoff (even more than Integrated Rule Curves) in below average water years. This water can then be released to augment spring flows (for white sturgeon and ESA salmon and steelhead) without impacting reservoir refill. The VARQ/Tiered Flow Approach is the most critical tool at our disposal to simultaneously balance the needs of resident and anadromous fish recovery by providing greater operational flexibility in dry years to help salmon/steelhead without harming native resident fish species.

The flow targets and KIRCs provide flexibility to assure that the runoff event corresponds with optimal water temperatures. A vertical array of thermometers on the upstream face of Libby Dam reveals the reservoir's thermal structure. As optimal water temperatures become available at the appropriate outlet depth, sturgeon releases can be shaped to achieve the optimal mix of flow and temperature.

The volume of the experimental flows are selected based on the May 1 inflow forecast volume (reservoir inflow expected during the period April 1 through September 30 in MAF). These targets represent minimum flows at Bonners Ferry (Libby Dam discharge plus unregulated inflows between Libby Dam and Bonners Ferry). When the forecast underestimates the actual inflow volume, minimum sturgeon flow targets are exceeded as excess water is released to slow the rate of reservoir refill (as dictated by the KIRCs). Overestimation results in the release of stored water to achieve the minimum flow target. In both cases, flows can be shaped through inseason management to achieve the most desirable balance between discharge shape and reservoir refill trajectory. For planning purposes, earlier inflow forecasts may be used to estimate the volume of the sturgeon release. Estimates should be updated as new forecasts become available.

The Libby Reservoir model was configured to automate the selection of flow targets and shape unexpected flow events resulting from forecasting error to within flood constraints. Analysis of the 50-year period of record (1929-1978) revealed that sturgeon targets can be met without impacting reservoir productivity. Sturgeon releases are not scheduled during low water years (lowest 20 percent) unless increased discharges are needed for emergency flood control.

Two of the fifty years of record (1948 and 1979) would require in-season management (increased sturgeon flows) for flood control. Water year 1974 was classified as a low water year (critical year 3), so under the tiered flow approach no flow augmentation would have occurred. Inflows were sufficiently high, however, that by late May it became obvious that the inflow forecasts were too low and that water must be released to maintain flood storage capacity behind Libby Dam. The model run was reprogrammed to simulate in-season management by releasing the appropriate sturgeon target (>8.5 MAF) to control the flood and avoid a forced spill. In reality, the 1974 flood was managed in nearly the same manner, providing adequate conditions for sturgeon as evidenced by successful recruitment from the 1974 year class (Apperson and Anders 1991).

Similarly, in 1948 the inflow forecast grossly underestimated the actual runoff volume. If Libby Dam had existed in 1948, the faulty inflow forecasts would not have warned dam operators to evacuate sufficient storage volume to control the flood. The corresponding sturgeon flow target based on the underestimated May 1 forecast would likewise not have maintained sufficient flood storage to reregulate the runoff. However, experienced dam operators would have been aware that the reservoir was refilling too rapidly and that a forced spill was imminent. To simulate this ability to respond to real time situations, we modified the 1948 simulation to release the maximum allowable sturgeon flow in response to the flood emergency.

Model evaluations revealed that impacts to the reservoir fishery can be reduced by implementing the VARQ flood control strategy. By explicitly storing water that would historically be released during winter, flows can be enhanced during June to create a more natural runoff event without impacting reservoir refill probability. VARQ creates greater flexibility for dam operation during less than average water years. Water released to provide more favorable conditions for sturgeon, continue downstream to aid juvenile anadromous smolt migrations to the Pacific Ocean. Westslope cutthroat and rainbow trout also respond favorably to a normalized spring discharge which corresponds with their life cycle requirements.

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Appendix D: Breeding Plan to Preserve the Genetic Variability of the Kootenai River White Sturgeon

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Contract No. DE-AI79-93BP02886

November 10, 1993

ACKNOWLEDGEMENTS

I thank Kimberly Apperson, Ned Horner, Paul Anders, and Gary Aitken for providing sturgeon culture and life history information and for consultation on development of the breeding plan. I thank Bernie May, Charles Krueger, Martin Dilauro, and James Meade for critical review of the final document. Rick Westerhof served as Project manager for Bonneville Power Administration on this project and was very helpful in providing hard-to-get published and unpublished reports on previous sturgeon research.

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EXECUTIVE SUMMARY

Natural reproduction in the Kootenai River white sturgeon population has not produced a successful year class since 1974, resulting in a declining broodstock and 20 consecutive year classes missing from the age-class structure. This report describes a captive breeding plan designed to preserve the remaining genetic variability and to begin rebuilding the natural age class structure.

The captive breeding program will use 3-9 females and an equal number of males captured from the Kootenai River each spring. Fish will be spawned in pairs or in diallel mating designs to produce individual families that will be reared separately to maintain family identity. Fish will be marked to identify family and year class before return to the river. Fish should be returned to the river as fall fingerlings to minimize potential adaptation to the hatchery environment. Initially, while tagging methods are tested to ensure positive identification after return to the river, it may be necessary to plant fish as spring yearlings. Number of fish planted will be equalized at 5,000 per family if fall fingerlings or 1,000 per family if spring yearlings. Assuming annual survival rates of 20% during the first winter for fall fingerling plants and 50% for years 1-3, and 85% for years 4-20 of all fish planted, the target numbers would yield 7.9 progeny per family or about 4 breeding pairs at age 20. Natural survival in the river environment during the 19+ years from planting to maturity would result in variability in genetic contribution of families to the next broodstock generation. Fish planted per family would be adjusted in future years when actual survival rate information is known. Broodfish will be tagged when captured to minimize multiple spawning of the same fish.

Implementation of this breeding plan each year for the 20-year generation interval, using 5 different mating pairs each year, will yield an effective population size of 200, or 22.5% of the estimated 1990 population. Because this captive breeding program is designed to produce approximately 8 breeding adults per family and to approximate a "normal expanding" natural population, it should not exaggerate the contribution of a small fraction of the parent population, as occurs in typical supplementation programs. This captive breeding plan should be discontinued once habitat is re-established to permit successful natural spawning and recruitment in the Kootenai River.

Breeding Plan to Preserve the Genetic Variability of the Kootenai River White Sturgeon

INTRODUCTION

The Kootenai River white sturgeon (Acipenser transmontanus) is a closed population residing in the Kootenai River between Kootenai Falls (50 km below Libby Dam) and Bonnington Falls (Corra Linn Dam). This population has been isolated from other Columbia River white sturgeon stocks for approximately 10,000 years (Northcote 1973). Estimates by Partridge (1983) and Apperson and Anders (1990) show the number of fish in the population declined from 1,148 in 1982 to 880 in 1990, a reduction of 27% in only 8 years. Fish numbers declined because reproduction and recruitment have been unsuccessful since 1974 (Apperson and Anders 1990, 1991). The threat of further decline in fish number and loss of genetic variability led local conservation groups to petition the U.S. Fish and Wildlife Service in June 1992 to list the Kootenai River white sturgeon as an endangered population under the Endangered Species Act of 1973 (Duke 1993).

Several steps have been taken to protect the Kootenai River white sturgeon. Fishing restrictions were imposed in Montana (fishery closed in 1979), Idaho (fishing limited to catch and release in 1984), and British Columbia (fishing limited to catch and release in 1984) to limit further losses. The Kootenai River White Sturgeon Committee, with representation from federal and state agencies, the Kootenai Tribe, and public interest groups, was formed in 1992 to undertake efforts to increase flow rate and restore natural river habitat. Efforts by management agencies to restore the habitat needed for sturgeon spawning and recruitment have yielded little progress to date. Until the habitat is restored, a systematic program to preserve the genetic diversity of this population should be implemented because natural aging processes (mortality and senility) and poaching will continue to reduce the population each year until it approaches extinction.

Natural reproduction has failed in this population for the past 19 years or the equivalent of one full generation. As a result, the natural age structure has been seriously disrupted and the effective population size reduced. Management agencies currently think that reproductive failure occurs because (1) adults fail to spawn due to lack of sufficient water flow to allow successful natural spawning (Apperson and Anders 1990, 1991), and (2) progeny fail to survive to the yearling stage due to lack of food supply, toxic contamination, or dewatering of nursery areas (Apperson and Anders 1990; Don Scaar, Montana Department of Fish, Wildlife, and Parks, personal communication). Flows in the Kootenai River from June to October have been much lower than historic flows since completion of Libby Dam in 1972. Spawning success would be affected if May-June flows are inadequate to attract mature fish to spawning areas or to support successful spawning. Low flows from July to September would also contribute to reduced larval survival by dewatering significant parts of the shallow larval feeding areas.

In the absence of natural reproduction and restoration of natural spawning conditions, a genetic preservation program must be initiated that includes limited culture. The wild adults remaining in the population must be spawned for an entire generation of year classes before these fish are irretrievably lost, if the existing genetic variability is to be preserved and a natural age structure re-established. The proposed program would capture wild fish, collect gametes, and produce the essential new generation. Progeny would be reared through the vulnerable juvenile stages (incubation, sac-fry, initial feeding fry, and fingerling stages) as separate families using procedures described by Conte (1988). Fish would be returned to the Kootenai River at the earliest life stage at which they could be recruited successfully and survive to maturity. The potential hazards of using captive culture (inbreeding, genetic drift, domestication, selection, behavioral conditioning, and exposure to disease) and the negative interactions of hatchery and wild fishes that effect the hatchery generation have been well documented (Hynes et al. 1981, Krueger et al. 1981, Kincaid 1983, Allendorf and Ryman 1987, Kapuscinski and Jacobson 1987, Waples 1991). However, waiting for restoration of natural reproduction is a more dangerous risk because the entire population is threatened. The continued decline in population size risks additional loss of genetic variability and possible extinction of the population.

Many of the potentially detrimental effects associated with captive culture can be reduced significantly by incorporating simple precautions into the breeding plan (Hynes et al. 1981, Krueger et al. 1981, Kincaid 1983, Allendorf and Ryman 1987, Kapuscinski and Jacobson 1987). These precautions include (1) plant fish at the earliest possible life stage, (2) maintain fish at low rearing densities during culture, (3) maintain high numbers of brood fish (effective population numbers), (4) equalize the genetic contribution of all parental fish to the next generation, (5) capture brood fish from throughout the fishery and spawning season, (6) spawn all mature adults available, and (7) avoid selection of brood fish and progeny based on physical appearance and captive performance.

This breeding plan provides a systematic approach to preserve the Kootenai River white sturgeon gene pool, while management agencies work to restore river habitat conducive to natural spawning and larval survival. Until a breeding plan is initiated, however, the number of fish in this population will continue to decline. This plan guides management in the systematic collection and spawning of wild adults before they are lost from the breeding population. This approach attempts to preserve a greater portion of the available genetic variability than "doing nothing while we wait" for restoration of natural spawning conditions.

<u>NOTE</u>: The captive breeding program outlined here should be discontinued when natural reproduction is re-established. If natural reproduction is not restored, however, the program must be continued every year for a minimum of one generation (a 20-year period) to restore the natural age structure. If the breeding plan is followed faithfully for the 20-year generation interval, it will yield a broodstock with an effective population size of approximately 200, or 22.7% of the current population.

OBJECTIVES

The objectives of the proposed breeding plan are as follows:

1. Describe a long-term breeding approach to preserve genetic variability.
2. Provide a multi-year breeding system to re-establish age structure.
3. Provide a breeding structure to create and maintain a "high" effective population size.
4. Describe "preservation stocking" methods to minimize potential detrimental effects of conventional supplemental stocking programs.
5. Describe small-lot cultural procedures to reduce the risk of detrimental genetic effects commonly associated with intensive hatchery production.
6. Describe a marking system to maintain family identity throughout the life cycle.

EFFECTIVE BREEDING POPULATION

The effective breeding number (N_e) for a population is the number of individuals in a random breeding population with an equal sex ratio, which would yield the same rate of inbreeding or genetic drift as the population being studied (Falconer 1981).

$$N_e = \frac{4 \times N_m \times N_F}{(N_m + N_F)}$$

This formula calculates the N_e (effective population size) for populations produced from random mating N_m male parents and N_f female parents. Ideally, N_e is calculated from counts of the actual number of parents that contribute progeny to the next broodstock generation. Because the actual number of individuals contributing progeny to the next generation and the number of progeny each contributes is unknown in most populations, the number of individuals that spawn and produce progeny is used in the calculation, i.e., the total number of fish spawned of each sex. For animal species with multi-year generation intervals, N_e is calculated using the sum of all males (N_m) and females (N_f) spawning each year for the number of years in the generation interval adjusted by any difference in sex ratio and the number of individuals that spawn more than once per generation. The generation interval is defined as the average age of females at first maturity, or about 20 years for the Kootenai River white sturgeon. The N_e will be the total of all spawners (different fish spawned) over the 20-year generation interval.

The situation assumed for the Kootenai River white sturgeon population produced under the proposed captive culture program is that (1) each fish spawns only once per generation, (2) each individual contributes progeny to a single generation (i.e., generations do not overlap), and (3) each parent contributes an equal number of progeny to the next generation. While white sturgeon can (and do) spawn multiple times during their reproductive life, the above conservative assumptions are reasonable because (1) the actual spawning frequency of white sturgeon in the Kootenai River is unknown, (2) little successful reproduction has been documented in this population since 1974 (about one generation) to contribute a progeny generation, and (3) the proposed breeding plan limits, but does not eliminate, multi-year spawning of individual fish.

Ideally, all sexually mature individuals should be spawned to contribute progeny to the next generation, to ensure the total parental gene pool is transmitted to the progeny generation. In the situation where a natural population is perpetuated by randomly sampling the parental generation, the minimum recommended number of founder stock to ensure the genetic integrity of the gene pool is 100 to 200 fish (Allendorf and Phelps 1980, Hynes et al. 1981, Krueger et al. 1981, Kincaid 1983). In light of the threatened status of Kootenai River white sturgeon, a random sample of 200 fish (100 males and 100 females) should be spawned to contribute progeny to the next generation over the next 20 years. This works out to an average of 10 brood fish (total of males and females) per year, i.e., 10 different fish each year for 20 years. While the actual number in any given year may be more or less, the average of 10 needs to be achieved to minimize the risk of losing genetic variability. The annual N_e values, for different numbers of males and females available for mating, are shown in Table 1. The practice of stocking equal numbers of progeny from each family will maximize N_e by reducing variability of family size and will also minimize any effects of domestication (Ryman and Laikre 1990, Allendorf 1993).

The Kootenai River white sturgeon restoration program will undertake concurrent thrusts: (1) to obtain higher water flows in the river to re-establish natural spawning habitat, and (2) to initiate a captive culture program to preserve the existing genetic variation until natural spawning is restored. As a result, a constraint is placed on the captive culture program to ensure that at least 50% of mature females in any given year are retained in the fishery and allowed to spawn "naturally," if river conditions permit. Reports by Apperson and Anders (1990, 1991) indicate 19-55 females are mature each year. Using the lower value, up to 9 females could be captured and spawned to produce fish for the culture program. To ensure that mature fish are available to spawn (naturally) in the river when adequate spawning conditions are present, any fish (male or female) not required for the cultural program must be returned to the river before the start of the spawning season.

ANNUAL BREEDING AND CAPTIVE CULTURE PLAN

This breeding plan requires the systematic capture of sexually mature wild fish from staging areas in the Kootenai River. Captured fish will be held for 1 to 2 months until ready to spawn. At maturity, each female will be spawned and the eggs fertilized with milt from one male (see mating design options that follow) to form a family. The resulting families will be incubated separately. After recovery from the spawning operation, wild brood fish will be returned to the river at the point of capture. When a family is hatched and before the fry begin to feed, it will be divided randomly into two or more separate tanks for rearing to the target stocking age. Throughout the cultural operation, special care must be taken to ensure that positive family identity is maintained. When tanks become overcrowded, fish will be divided randomly (i.e., no selection of fish except for gross abnormalities) into two tanks. When fish reach the target stocking age, equal numbers of fish from each family will be stocked into the river. Repeating the basic breeding plan each year over the entire generation interval will produce successive year classes to re-establish the natural age structure of the wild population. All fish that are surplus to stocking needs will be destroyed using approved euthanasia procedures.

NOTE: Surplus fish should not be retained in the program to avoid the temptation to plant (supplemental stocking) them, which is not desirable in programs designed to preserve the genetic variation of unique gene pools.

MATING DESIGN OPTIONS

The number of mature males and females captured from the fishery will vary from year to year, leading to the need for both single pair and half-sib family mating designs. Ideally, single pair matings (one male to one female) are preferred, with each fish used as a parent only once. However, in view of the difficulty in capturing sexually mature fish, the expectation that more males than females will be recovered, and the frequency of multiple recaptures of the same fish in successive years, the following rules for mating and handling fish will be followed.

1. When the number of spawning fish is 4 or more mating pairs (4 males and 4 females), mate one male to one female (using each fish as a parent in only one mating) to create totally unrelated families. Fish in excess of 8 pairs will be returned to the river and allowed to spawn naturally.
2. When there are 3 mature females in the captured broodstock, eggs from each female should be divided into 3 aliquots and mated to different males to form half-sib families for each female. Because males must not be used in more the one mating, a total of 9 males will be required. Males will be randomly assigned to the individual females. This will create a set of three half-sib families for each female, with no relationship between female half-sib family sets. Males in excess of 9 will be released and allowed to spawn naturally.
3. When there are 2 mature females in the captured broodstock, eggs from each female should be divided into 4 aliquots and mated to different males to form half-sib families for each female. Because males must not be used in more the one mating, a total of 8 males will be required. Males will be randomly assigned to the individual females. This will create a set of four half-sib families for each female, with no relationship between female half-sib family sets. Males in excess of eight will be released and allowed to spawn naturally.
4. When only one mature female is available, no lots will be spawned. All fish will be returned to the river and allowed to spawn naturally.
5. After a fish, male or female, has produced one (1) progeny family, it should not be spawned again for at least 5 years. If the fish is recaptured during the 5-year period, it should be released and allowed to spawn naturally. After 5 years, a fish could be used to produce a second family if no other unused fish are available for spawning. No fish should be used more that twice in the culture program, except females mated to multiple males in items 2 and 3 above. This rule serves to limit and equalize the genetic contribution of individual parents to the progeny generation under the captive culture program. Its primary effect will be to limit repeated use of males captured each year because the reported spawning frequency is 2-4 years for males and 3-10 years for females (Conte 1988). Fish that mature multiple years during the next 20 years will have the opportunity to contribute to the fishery through the captive culture program and natural spawning.
6. All fish not already tagged will be PIT (passive integrated transponder) tagged as they are captured and a permanent record established. Data recorded will include the capture location and the length, weight, and breeding history of each fish.

RECORD SYSTEM

Breeding history, recapture frequency, and progeny production information from each brood fish is essential for management to know the genetic contribution to the succeeding generation and the ultimate success of the long-term genetic variability maintenance program. The record system must contain at least the following information: (1) identity of individual brood fish, (2) progeny family identification, (3) progeny year-class identification, (4) number of progeny stocked per family, (5) survival of each family to maturity, and (6) contribution of each family to the next captive broodstock generation.

A tagging system (PIT tags) to provide positive identification of parental fish will be essential for development of breeding history information to allow biologists to limit the genetic contribution of individuals captured year after year. A marking system will also be essential to identify families and year classes for determination of post-stocking survival and subsequent genetic contribution to the next generation. Because PIT tags are expensive and too large for subyearling fish, they are not suitable for use on fall fingerlings. A multiple mark system, using a combination of coded-wire tags and scute removal (Rein et al. 1993), would provide positive identification of families, year-classes, and hatchery origin needed to accommodate a subyearling planting program. The coded-wire tag would identify that a fish was produced by a captive broodstock mating and would provide family and year-class information. Scute removal in specific locations would also provide a visual mark to identify the family and the year-class of all fish planted. When fish are recovered from the fishery at a later age, they would be identified by reading the scute record then PIT tagged to initiate the individual and family record. As fish are recaptured in the future, tag number, distinguishing mark, length, weight, recovery location, and recovery date will be recorded in the permanent record. Information gained from this program will allow managers to evaluate survival, growth, and reproduction on a family basis.

TARGET STOCKING NUMBER

The recruitment goal for each family in this program is "enough fish to produce 4 to 10 adults at 20 years of age." This number will allow the broodstock population to expand slowly with a "natural" variability in family contribution to the succeeding generation. The genetic contribution of each family will be limited by the number of fish planted, and each brood fish will be limited by the number of times its gametes are used in captive matings. Variation in the number of progeny contributed to the next broodstock generation will occur naturally because of differential survival resulting from natural selection and random chance after the fish are returned to the river. The primary difficulty in determining the number of fish to stock from each family is a lack of information on post-stocking survival of juvenile white sturgeon from age 0 to age 20. This lack of information prevents calculation of optimal stocking rates based on age at stocking. In addition, normal year-to-year environmental variation in precipitation, flooding, flow rates, temperature, predator populations, and food supply can create wide variation in annual and long-term survival.

A range of survival rates at successive life stages can be modeled, leading to very different optimum planting rates (Table 2). If fish are planted at age 1+ and have annual survival rates of 50% the first year, 60% the second, 70% the third, and 80% thereafter through the 18th year (age 20), a 1,000 fish plant will yield 7 brood fish at age 20 (Case 5, Table 2). Based on these assumptions, stocking 1,000 fish per family would produce the 4-10 breeding adults desired in the next broodstock generation. Until better information is developed, a target of 1,000 yearling or 5,000 fall fingerlings (age, 3-6 months) should be planted per family. These numbers would be adjusted when recovery data from the initial plantings become available.

PRESERVATION STOCKING

The standard concept of supplemental stocking is that large numbers of fish are reared to the fingerling or yearling stage, then planted on top of a "natural" population to expand the production of that fishery. The goal of a supplemental stocking program is typically to expand the population or increase production of a fishery; little attention is given to preservation of the existing gene pool. The term "preservation stocking" is used here to indicate that preservation of genetic variability is the primary objective of the program; "slow" expansion of the population is a secondary goal. Undesirable effects commonly associated with supplemental stocking occur when the hatchery product (1) competes with wild fish for food and rearing space, resulting in reduced survival of the wild fish; (2) competes with wild fish for spawning habitat, resulting in reduced reproduction of the wild fish; and (3) interbreeds with wild fish, resulting in the introduction of hatchery-adapted genes, which dilute the genetic attributes and gene complexes that enhance "wild" survival, growth, and reproductive performance. This plan differs from "conventional" supplemental stocking in several ways. First, because the current broodstock has not reproduced successfully since 1974, there is no reproducing population of white sturgeon in the Kootenai River to compete and interbreed with fish planted under this plan. Second, the number of fish planted will be small compared with conventional supplemental stocking programs. The number of fish planted per family will be equalized at a level designed to produce only 2-5 times broodstock replacement numbers.

The objective of this plan is to preserve the existing gene pool; therefore, the number of fish planted will represent equal numbers from all available families and will be only enough to produce 4-10 adults per family at maturity. As individual fish will be used as parents only once every 5 years, the likelihood of inbreeding in future generations will be reduced. Effects of preservation stocking, as outlined under this plan, do not pose a threat to the genetic composition of the existing gene pool. Conversely, this plan offers an approach for preserving the genetic variability remaining in this seriously threatened, declining white sturgeon population.

RECOMMENDATIONS FOR OTHER STEPS TO AID RESTORATION

During the initial stages of this program major efforts should be made to collect additional genetic information on the Kootenai River white sturgeon, to develop cultural technology to rear multiple small lots, and to develop nonsurgical spawning techniques.

1. Limited genetic baseline information (Setter and Brannon, 1992) and no breeding history are available on the Kootenai River White sturgeon. Because there is a high probability that actual effective population size is much less than indicated by the 1990 estimate of population size (880 individuals), a refined estimate of N_e would be valuable. The linkage disequilibrium method (Bartley et al. 1992) for N_e estimation would be appropriate and should be applied over the next 2 years. Non-lethal tissue samples (blood, muscle, and scute) could be taken from fish captured during routine netting operations for population assessment and broodstock capture. Tissue samples from each fish captured over a 2-year period (about 25-40 fish) would provide the information necessary to estimate N_e. This information would help determine the urgency of implementing restoration efforts and provide guidance for adjustments to the proposed breeding plan.
2. The goal for the cultural operation will be an annual production of 8-12 separate lots (families), each consisting of 5,000 fingerlings or 1,000 yearlings for stocking in the Kootenai River. This is new technology for many culturists and fishery biologists. Hatchery facilities will need to be re-designed and modified to accommodate these small groups effectively. Cultural practices and procedures will also need revision to provide reduced rearing densities, introduce special precautions to ensure absolute separation of family groups during culture, and implement tagging systems to give positive identification of individuals throughout the life cycle.
3. Techniques are needed for reliable, nonsurgical spawning of white sturgeon. Currently, most females are spawned by surgical removal of the eggs. The fish must then be held in the hatchery until the incision is healed. This means that while the female produced several hundred thousand eggs, only those retained for culture are available to the fishery; the remaining eggs are lost. Methods are needed to allow fish to be released after the initial spawning to complete spawning naturally in the river. If this is not possible, an alternative would be development of methodology to release fertilized eggs in "appropriate" spawning sites. A means

is needed to ensure that gametes produced "in the river" can be used for both captive and natural spawning to provide maximum likelihood that the genetic variability of the Kootenai River white sturgeon will be preserved.

COMPARISON OF RESTORATION APPROACHES

Two approaches are proposed to restore white sturgeon in the Kootenai River. The first approach is to restore water flows in the Kootenai River, during the spawning season and developing fry period, to levels approaching those recorded in the early 1970's and known to support successful reproduction of white sturgeon. There is high expectation that increased water flow will support natural spawning, which will increase population number and begin to restore a natural age class structure. The advantage of this approach is that it is natural, and fish would not be subjected to hatchery culture, thereby avoiding potential domestication and exposure to disease organisms. The disadvantage is that population size would continue to decrease, with the associated loss of genetic variability, until the natural spawning habitat is restored. Despite high expectation, however, the possibility exists that increasing water flows alone may not restore natural spawning. If this were the case, and in light of the time needed for verification of successful spawning and recruitment, it could be several years before the true situation became known. During the period of verification, population size would continue to decline, and more of the older fish would become senile. The result would be continued disruption of age class structure, with additional missing year classes. If water flows to support natural spawning are not provided every year, the problem of verification of the true situation will be exacerbated because fewer juveniles would be available for capture.

The second approach, use of the captive breeding program described here, has the following advantages: (1) rebuilding the age structure would begin immediately, with a random portion of the mature broodfish each year contributing progeny to the next generation. All of these fish are currently lost to the fishery because of inadequate natural spawning habitat; (2) increased numbers of broodfish would contribute to the next generation before they were lost to senility or death; and (3) higher numbers of fish would survive to ages that could be successfully recruited into the population. Disadvantages include (1) increased exposure of broodfish and progeny to the cultural environment, i.e., artificial feed, tanks, handling, and diseases; (2) unavailability of captive fish to spawn naturally if suitable spawning conditions were present in the river; and (3) increased costs to produce and tag fish over several years.

The idea that these two approaches are incompatible is a misconception. There is no biological reason to prevent simultaneous implementation of both approaches. Indeed, when the advantages and disadvantages of both approaches are considered in light of the current "threatened" status of the Kootenai River white sturgeon, simultaneous implementation of both approaches seems to offer the highest probability to protect and preserve the genetic variability of the Kootenai River white sturgeon.

The captive breeding plan allows management to begin the long-term process of re-establishing the natural age structure, using progeny from a random sample of the mature broodfish each year, before the population is reduced further. Captive breeding should be continued until evidence is available to show that natural reproduction is yielding adequate recruits to sustain the genetic variability of the population. Likewise, work to re-establish flow rates capable of supporting "quality" spawning and rearing habitat for all life stages should move forward as quickly as possible. Once natural habitat for sturgeon has been re-established, the captive breeding program should be discontinued. The two approaches are supportive of each other and not incompatible when applied properly.

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Table 1. Effective population number based on the actual number of males and females used to produce the progeny generation. Identify the number of females in columns and the number of males in rows; the calculated effective breeding number for this combination can be read at the column and row intersection.

Number male parents	Number female parents											
	1	2	3	4	5	6	7	8	9	10	11	12
1	2.0	2.7	3.0	3.2	3.3	3.4	3.5	3.6	3.6	3.6	3.7	3.7
2	2.7	4.0	4.8	5.3	5.7	6.0	6.2	6.4	6.5	6.7	6.8	6.9
3	3.0	4.8	6.0	6.9	7.5	8.0	8.4	8.7	9.0	9.2	9.4	9.6
4	3.2	5.3	6.9	8.0	8.9	9.6	10.2	10.7	11.1	11.4	11.7	12.0
5	3.3	5.7	7.5	8.9	10.0	10.9	11.7	12.3	12.9	13.3	13.8	14.1
6	3.4	6.0	8.0	9.6	10.9	12.0	12.9	13.7	14.4	15.0	15.5	16.0
7	3.5	6.2	8.4	10.2	11.7	12.9	14.0	14.9	15.7	16.5	17.1	17.7
8	3.6	6.4	8.7	10.7	12.3	13.7	14.9	16.0	16.9	17.8	18.5	19.1
9	3.6	6.5	9.0	11.1	12.9	14.4	15.7	16.9	18.0	19.0	19.8	20.6
10	3.6	6.7	9.2	11.4	13.3	15.0	16.5	17.6	19.0	20.0	21.0	21.8
11	3.7	6.8	9.4	11.7	13.8	15.5	17.1	18.5	19.8	20.6	22.0	23.0
12	3.7	6.9	9.6	12.0	14.1	16.0	17.7	19.1	20.6	21.8	23.0	24.0

Table 2. Expected survival of white sturgeon for an 18-year period after planting, under different scenarios of annual survival rates. All examples are calculated on an initial stocking of 1,000 fish.

Years	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
in river	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish
1	0.5	500	0.5	500	0.5	500	0.50	500	0.5	500	0.50	500
2	0.5	250	0.6	300	0.6	300	0.60	300	0.6	300	0.60	300
3	0.5	125	0.6	180	0.7	210	0.70	210	0.7	210	0.70	210
4	0.5	63	0.6	108	0.7	147	0.75	158	0.8	168	0.80	168
5	0.5	31	0.6	65	0.7	103	0.75	118	0.8	134	0.85	143
6	0.5	16	0.6	39	0.7	72	0.75	89	0.8	108	0.85	121
7	0.5	8	0.6	23	0.7	50	0.75	66	0.8	86	0.85	103
8	0.5	4	0.6	14	0.7	35	0.75	50	0.8	69	0.85	88
9	0.5	2	0.6	8	0.7	25	0.75	37	0.8	55	0.85	75
10	0.5	1	0.6	5	0.7	17	0.75	28	0.8	44	0.85	63
11	0.5	0	0.6	3	0.7	12	0.75	21	0.8	35	0.85	54
12	0.5	0	0.6	2	0.7	9	0.75	16	0.8	28	0.85	46
13	0.5	0	0.6	1	0.7	6	0.75	12	0.8	23	0.85	39
14	0.5	0	0.6	1	0.7	4	0.75	9	0.8	18	0.85	33
15	0.5	0	0.6	0	0.7	3	0.75	7	0.8	14	0.85	28
16	0.5	0	0.6	0	0.7	2	0.75	5	0.8	12	0.85	24
17	0.5	0	0.6	0	0.7	1	0.75	4	0.8	9	0.85	20
18	0.5	0	0.6	0	0.7	1	0.75	3	0.8	7	0.85	17

Years	Case 7		Case 8		Case 9		Case 10		Case 11		Case 12	
in river	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish	% surv.	No. fish
1	0.6	600	0.3	300	0.3	300	0.40	400	0.2	200	0.20	200
2	0.8	480	0.4	120	0.4	120	0.60	240	0.4	80	0.50	100
3	0.9	432	0.8	96	0.9	108	0.75	180	0.6	48	0.60	60
4	0.9	389	0.8	77	0.9	97	0.75	135	0.8	38	0.70	42
5	0.9	350	0.8	61	0.9	88	0.75	101	0.9	35	0.80	34
6	0.9	315	0.8	49	0.9	79	0.75	76	0.9	31	0.80	27
7	0.9	283	0.8	39	0.9	71	0.75	57	0.9	28	0.85	23
8	0.9	255	0.8	32	0.9	64	0.75	43	0.9	25	0.85	19
9	0.9	230	0.8	25	0.9	57	0.75	32	0.9	23	0.90	18
10	0.9	207	0.8	20	0.9	52	0.75	24	0.9	20	0.90	16
11	0.9	186	0.8	16	0.9	47	0.75	18	0.9	18	0.95	15
12	0.9	167	0.8	13	0.9	42	0.75	14	0.9	17	0.95	14
13	0.9	151	0.8	10	0.9	38	0.75	10	0.9	15	0.95	14

Table 2. Continued.

Years in river	Case 7 % surv.	Case 7 No. fish	Case 8 % surv.	Case 8 No. fish	Case 9 % surv.	Case 9 No. fish	Case 10 % surv.	Case 10 No. fish	Case 11 % surv.	Case 11 No. fish	Case 12 % surv.	Case 12 No. fish
14	0.9	136	0.8	8	0.9	34	0.75	8	0.9	13	0.95	13
15	0.9	122	0.8	7	0.9	31	0.75	6	0.9	12	0.95	12
16	0.9	110	0.8	5	0.9	28	0.75	4	0.9	11	0.95	12
17	0.9	99	0.8	4	0.9	25	0.75	3	0.9	10	0.95	11
18	0.9	89	0.8	3	0.9	22	0.75	2	0.9	9	0.95	10

Table 3. Continued.

Count of years	Years	Survival calculation (3.26%)	Annual rate of loss from the population (%)									
			1	2	3	4	5	6	7	8	9	10
135	2125	10	227	58	14	4						
140	2130	8	215	52	12	3						
145	2135	7	205	47	11	2						
150	2140	6	195	43	9							
155	2145	5	185	38	8							
160	2150	4	176	35	7							
165	2155	4	168	31	6							
170	2160	3	159	28	5							
175	2165	3	152	26	4							
180	2170	2	144	23	4							
185	2175		137	21	3							
190	2180		130	19	3							
195	2185		124	17	2							
200	2190		118	15	2							
205	2195		112	14								
210	2200		107	13								
215	2205		101	11								
220	2210		96	10								
225	2215		92	9								
230	2220		87	8								
235	2225		83	8								
240	2230		79	7								
245	2235		75	6								
250	2240		71	6								
Project years to extinction		191	643	324	209	155	123	102	87	76	67	60

Table 3. Expected population size at 5 year intervals during the 250 year period from 1982 to 2340 are calculated, assuming an initial population of 880 and constant annual mortality rates of 1 to 10%. A 3.26% annual mortality rate (calculated mortality rate from 1982 and 1990 population estimates) is projected to show the current rate of population decline. Time to extinction was calculated for each mortality rate.

Count of years	Years	Survival calculation (3.26%)	Annual rate of loss from the population (%)									
			1	2	3	4	5	6	7	8	9	10
5	1995	745	837	795	756	718	681	646	612	580	549	520
10	2000	631	796	719	649	585	527	474	426	382	343	307
15	2005	535	757	650	557	477	408	348	296	252	214	181
20	2010	483	720	587	479	389	315	225	206	166	133	107
25	2015	383	684	531	411	317	244	187	143	109	83	63
30	2020	325	651	480	353	259	189	138	100	72	52	37
35	2025	275	619	434	303	211	146	101	69	48	32	22
40	2030	233	589	392	260	172	113	74	48	31	20	13
45	2035	197	565	362	223	140	88	54	34	21	13	8
50	2040	167	532	320	192	114	68	40	23	14	8	5
55	2045	141	506	290	165	93	52	29	16	9	5	
60	2050	120	481	262	142	76	41	21	11	6		
65	2055	101	458	237	122	62	31	16	8	4		
70	2060	86	435	214	104	51	24	12	5			
75	2065	73	414	193	90	41	19	8	4			
80	2070	62	394	175	77	34	15	6				
85	2075	52	375	158	66	27	11	5				
90	2080	44	356	143	57	22	9	3				
95	2085	37	339	129	49	18	7	2				
100	2090	32	322	117	42	15	5					
105	2095	27	306	105	36	12	4					
110	2100	23	291	95	31	10	3					
115	2105	19	277	86	26	8	2					
120	2110	16	263	78	23	7						
125	2115	14	251	70	20	5						
130	2120	12	238	64	17	4						

Appendix E. White sturgeon broodstock collection protocols.

Purpose: Develop genetically sound guidelines for Kootenai River white sturgeon broodstock collection and mating design options.

- This protocol is designed to maximize white sturgeon broodstock collection efficiency, reproductive success and genetic variation of broodstock while maximizing negative effects of handling stress on the wild population. It is also designed to minimize negative effects of broodstock collection on natural spawning of white sturgeon in the Kootenai River.

- Broodstock should be collected from a wide geographic and temporal range to maximize genetic variability of individual white sturgeon broodstock for the Kootenai Hatchery.

- While genetic variation (heterozygosity) among individuals in the Kootenai River white sturgeon population is currently unknown, this approach is designed to maximize the diversity of genetic material passed on from the spawned adults to the F1 generation produced in the Kootenai Hatchery.

- Collect and spawn 3 to 6 ripe females and 6 to 9 ripe males annually for spawning in the Kootenai Hatchery for a 10 consecutive year period (1996 through 2005) in the following fashion, with a goal of approximating an annual spawning population number of 10:

Number of females	Max. # of males	Maximum Spawning Population	Max. # of Families
3	9	9.0	9
4	8	10.7	8
5	5	10.0	5
6	6	12.0	6

- Broodstock collection can occur anywhere in the Kootenai River before the first day of egg mat deployment.

- o No egg mats will be placed in the Kootenai River downstream from Burton Creek (rkm 227.7).

- o When augmented flows in the spring increase or ramp up at a rate $\geq$ 4,000 cfs/day, IDFG may remove egg sampling mats from the Kootenai river for a maximum of three days. The IDFG will notify KTOI at least 24 hours before egg mat removal and 24 hours before re-deployment. During this three day period, the KTOI can fish for white sturgeon broodfish anywhere downstream from Myrtle Creek (rkm 235.6) until mats are re-deployed.

- o Fishing to collect hatchery broodstock can begin as early as April 1, and continue until July 1, 1996 downstream from rkm 227.5 and in other areas according to the following conditions:

- o The Shorty's Island area (approx. rkm 230-231): This one kilometer reach is reserved exclusively for broodstock collection; no egg mats will be deployed in this reach. This reach will be identified in the field as the pumping station outlet (upstream end) to rkm 230 on the downstream end (marked with stake and flagging on each side of the river)

- o No broodstock collection can occur upstream from Shorty's Island <u>with one exception</u>: If no gravid females are in the Kootenai Hatchery by May 15, 1996, then up to 2 gravid females may be taken from Ambush Rock (rkm 243.5 - 224.6, mill boat ramp). No egg mats will be placed in this river section under this condition.

- o White sturgeon fitted with active radio or sonic transmitters captured during broodstock collection will <u>not</u> be brought to the Kootenai Hatchery to be spawned; they must be released unharmed as quickly as possible.

- o As soon as white sturgeon broodstock collection is completed, all areas of the Kootenai River are available for egg larval sampling.

APPENDIX F: Summary of the Public, Agency, and Peer Review Comments on the Draft Kootenai River White Sturgeon Recovery Plan.

On July 2, 1996, the Fish and Wildlife Service released the Draft Recovery Plan for the Kootenai River population of white sturgeon for a 90-day comment period that ended September 30, 1996, for Federal agencies, State and local governments, members of the public and peer review (61 Federal Register 34441).

Eighteen letters were received, each containing varying numbers of comments. The Fish and Wildlife Service also sent letters to seven "experts" in the field of white sturgeon biology and conservation requesting comments on the Draft Recovery Plan. Responses were received from four of these experts, who provided comments and recommendations on the proposed conservation aquaculture program, the adequacy of ongoing monitoring and research activities, and on the downlisting and delisting criteria.

Number of letters received, by affiliation:

Federal agencies	4 letters
State and local governments	5 letters
Business and industry	1 letter
Canada	3 letters
Native American Tribes	1 letter
General public	2 letters
Academia and professionals	2 letters

Summary of Significant Comments and Fish and Wildlife Service Responses

The Fish and Wildlife Service reviewed all of the comments received during the comment period. Many specific comments reoccurred in the letters. Comments updating the information in the draft recovery plan have been incorporated into the appropriate section of this final recovery plan. The substantive comments and the Fish and Wildlife Service's response to each are summarized as follows:

Comment 1: Statements in the draft recovery plan appear to relegate white sturgeon recovery to a lesser status than Snake River salmon recovery.

Response 1: The Fish and Wildlife Service disagrees and attempts have been made to correct this misconception. Recovery plans describe reasonable actions that are believed necessary to recover and protect threatened or endangered species. Recovery actions cannot occur without full consideration of their effects on other resources, including other listed species. In this example, proposed changes in Libby Dam operations to benefit white sturgeon may need to be modified in future years under certain environmental conditions (i.e. drought or low water conditions) to benefit listed Snake River salmon. The National Marine Fisheries Service has yet to complete a final recovery plan for salmon. Therefore, we cannot discuss how the National Marine Fisheries Service recovery plan complements white sturgeon recovery in the Kootenai River.

Libby Dam is the only facility in the United States within the Columbia River basin that affects Kootenai River white sturgeon and other facilities in the United States could provide comparable water volumes for salmon recovery needs. The Fish and Wildlife Service and National Marine Fisheries Service have informally agreed that should recommendations for listed Snake River salmon pose unacceptable risks to white sturgeon survival and recovery, the National Marine Fisheries Service would defer and recommend water releases from other Columbia River facilities.

Comment 2: The recovery plan should clarify the statement "...In most years, the plan should complement conservation measures designed by the National Marine Fisheries Service to meet Snake River chinook and sockeye salmon recovery objectives downstream in the Columbia River."

Response 2: Language has been inserted to clarify that balance with salmon recovery is achievable in "...all but the most extreme low water years...."

Comment 3: Language added to the draft recovery plan "...or meeting section 7 requirements for Snake River salmon.." creates a situation in dry years where Libby Dam releases would impact reservoir refill and impact the system's ability to meet flow targets the following year.

Response 3: The Fish and Wildlife Service agrees that in low flow years, requests for Kootenai River flows to meet section 7 requirements for listed salmon downstream will impact Koocanusa Reservoir refill probability. Although there would be no additional spring flow requests for white sturgeon during low flow years (e.g., critical water years 3 or 4), additional demands for Kootenai River water may need to be addressed.

Comment 4: Will you ever be able to define what is needed and develop recovery criteria for habitat restoration or when the white sturgeon population can be down listed or delisted?

Response 4: Specific recovery criteria have been developed. They will be refined as new population status, life history, biological productivity, and flow augmentation monitoring information is collected. Recovery will require that natural reproduction occurs and a demonstration that Kootenai River environmental conditions that produce natural reproduction are repeatable.

Comment 5: State a time frame for developing delisting criteria.

Response 5: The following language has been added "...it will be approximately 25 years following approval of this recovery plan before delisting of the white sturgeon population can be considered. Twenty-five years is the approximate period for female white sturgeon added to the population during the next 10 years to reach maturity and reproduce to complete a new generation or spawning cycle."

Comment 6: The final recovery plan should provide more clarity regarding what version of Integrated Rule Curves will be used for white sturgeon recovery.

Response 6: The final recovery plan includes a thorough description and evaluation of effects of the proposed Kootenai Integrated Rule Curves (KIRCs) (see Appendix B).

Comment 7: The Army Corps of Engineers has determined that the Integrated Rule Curves do not provide adequate flood storage in the highest runoff years. The Army Corps of Engineers is investigating a variable release strategy for flood control (VARQ) that could allow the implementation of an Integrated-Rule-Curves-type operation in many years of low to moderate runoff, but will supersede Integrated Rule Curves in above average volume runoff years.

Response 7: The proposed Kootenai Integrated Rule Curves reconciles differences between Integrated Rule Curves and variable release strategy to address flood control concerns.

Comment 8: The National Marine Fisheries Service's 1995 Biological Opinion on the operation of the Federal Columbia River Power System is consistent with the operational requirements at Libby Dam for Kootenai River white sturgeon.

Response 8: This recovery plan attempts to restore more normative Kootenai River flows, and it is difficult to justify support of August or late summer flows that are three to five times greater than those of a natural, unregulated hydrograph, as outlined in the Biological Opinion. Summer flushing of epilimnetic water from Kootenay Lake adversely affects invertebrate and fish production. It is the Fish and Wildlife Service's hope that other United States facilities could provide the necessary volumes of water for salmon recovery while retaining as much of the natural hydrograph as possible on the Kootenai River.

Comment 9: Montana's Integrated Rule Curves conflict with the National Marine Fisheries Service's Biological Opinion and the National Marine Fisheries Service's proposed recovery plan for Snake River salmon. Moreover, the National Marine Fisheries Service "...cautioned that it could undermine the federal government's position to protect both endangered salmon and sturgeon if USFWS white sturgeon plan supported Libby Dam Integrated Rule Curves."

Response 9: As stated in response 8, it is difficult to justify support of August or late summer flows that are three to five times greater than those of a natural, unregulated hydrograph. However, this apparent conflict has been successfully mitigated by up to a 50 percent August flow reduction achieved through negotiations with BC Hydro. With National Marine Fisheries Service support we may find a way to firm up water exchanges or establish new strategies such as limited manipulation of Kootenay Lake for storage of salmon flow water. Future decisions pending on John Day Reservoir drawdown proposals for the lower Columbia River could greatly diminish the need for later summer Kootenai River water releases.

Comment 10: Nothing in the Draft Sturgeon Plan suggests that it is necessary to the recovery of Kootenai River sturgeon to use operational guidelines based upon Integrated Rule Curves. "The National Marine Fisheries Service 'strongly' suggests that the final Plan adopt the Opinion operation at Libby Dam...."

Response 10: See response 9.

Comment 11: The Idaho Department of Fish and Game has "...some serious reservations about the Conservation Culture Plan." These "...programs should be experimental and short-lived; no longer than ten years."

Response 11: The recovery team and the Fish and Wildlife Service believe the conservation aquaculture program, as described in the final recovery plan and based on available information, is a necessary component of recovery to prevent the near-term extinction of the white sturgeon population. The following language has also been inserted in Part II, Recovery Criteria to address the 10-year limit, "...the Fish and Wildlife Service may recommend that the conservation aquaculture program be extended beyond 10 years if adequate natural reproduction to support full protection of the existing Kootenai River white sturgeon gene pool is not clearly demonstrated."

Comment 12: The Idaho Department of Fish and Game recommends that the conservation culture program, if implemented, adhere to the "Kincaid Plan", and that "...Strict disease protocols must be identified and enforced."

Response 12: The Fish and Wildlife Service agrees. The proposed conservation aquaculture program is based primarily on the breeding plan developed by Harold Kincaid in 1993. Recovery task 242 describes the development of a fish health plan for hatchery-reared white sturgeon, including disease protocols.

Comment 13: Adult broodstock should possibly be reared in a hatchery as a genetic reserve to produce offspring in the event of a "...disastrous population collapse."

Response 13: We agree that such a conservation measure may become appropriate in the future, however, such an action at this time was deemed premature because of the current wild population size and proposed conservation culture program.

Comment 14: Why was the conservation plan submitted by the Kootenai Tribe of Idaho in 1994 not accepted at that time in lieu of listing?

Response 14: During the public comment period on the proposed rule, the Fish and Wildlife Service received recovery strategies from the Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; and the Kootenai Tribe of Idaho. The Fish and Wildlife Service evaluation of the strategies indicated that they did not sufficiently reduce the threats to sturgeon and improve their status to eliminate the need for protection under the Endangered Species Act. However, these strategies were reviewed by the Fish and Wildlife Service and were useful in describing the major issues, and developing tentative solutions and quantifiable goals for Kootenai River white sturgeon as described in the recovery plan.

In addition, the Fish and Wildlife Service was unable to develop a prelisting conservation agreement with the Federal action agencies.

Comment 15: How will proposed recovery actions affect Kootenay Lake elevations and consequently recreation and beach access in British Columbia?

Response 15: With the regulation of inflows by Libby Dam the interpretation of the International Joint Commission (IJC) Order has resulted in Kootenay Lake mean maximum levels being more than 2 meters (6.6 feet) lower since the construction and operation of Libby Dam in 1974. The lower maximum lake elevation may have contributed to the lack of successful white sturgeon reproduction in the Kootenai River by altering river stage, flow velocity, and substrate relationships in the vicinity of sturgeon spawning habitat near Bonners Ferry. Specific impacts to Kootenay Lake elevations and associated beaches are not known at this time since elevations necessary for successful white sturgeon recruitment are not yet known (see recovery task 32 for a more complete discussion of this issue).

Discussions to date have been confined to seasonal adjustments within the operating prescriptions of the 1938 International Joint Commission Order. Further, these adjustments have been limited to those elevations below which significant recreation facilities and other developments have encroached in the Kootenai River flood plain since 1974.

Comment 16: Some of the draft recovery plan's recommended actions are not evenly applied.

Response 16: The Fish and Wildlife Service evaluated all currently known threats to the population and developed a prioritized list of recommended actions and activities to "...reestablish natural recruitment, minimize additional loss of genetic variability to the white sturgeon population, and successfully mitigate biological and physical habitat changes caused by the construction and operation of Libby Dam...."

Comment 17: The Fish and Wildlife Service should amend the "...plan to reflect the need for a more natural hydrograph during the entire residency of spawning and rearing sturgeon in the Kootenai River."

Response 17: We believe this has been addressed adequately through recovery activities designed to identify and restore white sturgeon habitats necessary to sustain white sturgeon reproduction (spawning and early age recruitment) and rearing while minimizing effects on other uses of Kootenai River basin waters, e.g. recreational facilities and the resident fishery in Koocanusa Reservoir.

Comment 18: The effects of early 1900's diking along the Kootenai River have not been adequately addressed in the draft recovery plan as a significant factor in the white sturgeon population decline.

Response 18: The elimination of side-channel slough habitats in the Kootenai River is acknowledged as a contributing factor in the white sturgeon's decline. In a more normative condition, sloughs and the flood plain provide habitat for fish sites, for sediment deposition, and for nutrient exchange. These areas have been eliminated by diking and channelization. Recovery task 122 seeks to identify opportunities to restore flood plain functions along the Kootenai River using available State and Federal funds. The task recommends finding landowners in flood-prone areas that may be willing to sell, lease, or assign conservation easements on portions of their land suitable for restoring natural flood plain functions.

Comment 19: The final recovery plan should clarify statements regarding current level of pollution to the Kootenai River.

Response 19: Language has been added to the recovery plan to clarify that fertilizer processing, lead-zinc mine, and vermiculite pollutant discharges have been eliminated.

Comment 20: Do other spawning areas, besides the Kootenai River, exist for this population of white sturgeon.

Response 20: There is no evidence that white sturgeon spawn in areas outside the Kootenai River.

Comment 21: Inventories on all aquatic species should be routine if possible.

Response 21: Recovery tasks 51 through 56 deal with other native fish species in the Canadian and United States portions of the Kootenai River drainage.

Comment 22: The recovery plan should outline possible mechanisms of impact to Kootenai River white sturgeon from the collapse of the kokanee population in Kootenay Lake.

Response 22: The long-term decline in kokanee stocks has been attributed to a decrease in biological productivity in Kootenay Lake. Kokanee were once considered an important prey item for adult white sturgeon. Recovery tasks 331 and 332 have been added to partially address the productivity issue, including the role of Kootenay Lake kokanee in white sturgeon recovery.

Comment 23: The recovery plan "...is based on allocating a higher priority to the Kootenai white sturgeon than to other Canadian fish stocks."

Response 23: Recovery plans provide information and guidance the Fish and

Wildlife Service believes will lead to recovery of listed species, in this case the Kootenai River white sturgeon . This recovery plan places high priority on those actions that must be taken to prevent extinction or further decline in the near future. However, recovery objectives are designed to balance white sturgeon recovery measures with requirements for other aquatic species and recreational fisheries within the United States and Canada portions of the Kootenai River drainage.

Comment 24: The question of who is responsible for mitigation and/or compensation from these proposed operational changes that will impact Canadian fisheries and other water uses should be addressed.

Response 24: At this point, the Fish and Wildlife Service is unaware of specific Canadian fisheries impacts requiring mitigation as a result of white sturgeon operations. The issues of impacts to Canadian power generation and other water uses are still being considered by the governments of Canada and the United States.

Comment 25: Are there natural reasons why abundance has declined as well as the usual man-made changes?

Response 25: Like many river ecosystems, the Kootenai River corridor has been considerably altered by human influences. We lack sufficient early data to say whether natural causes are responsible for any of the declines.

Comment 26: Was there any evidence of missing year classes in the past (prior to the construction and operation of Libby Dam)?

Response 26: Study results presented by Partridge (1983) and Apperson and Anders (1991) demonstrate that white sturgeon recruitment has been intermittent prior to the construction of Libby Dam. This is demonstrated by the absence of year classes 1965 to 1969, 1971 to 1973, and 1975.

Comment 27: Sturgeon are not doing well in other areas. Are there similar reasons for decline similar to those demonstrated for the Kootenai River population?

Response 27: With few exceptions, most wild sturgeon populations throughout the world are declining due to the combined effects of dam construction, over fishing, and water pollution.